NOVEMBER-DECEMBER 1960

ORDNANCE

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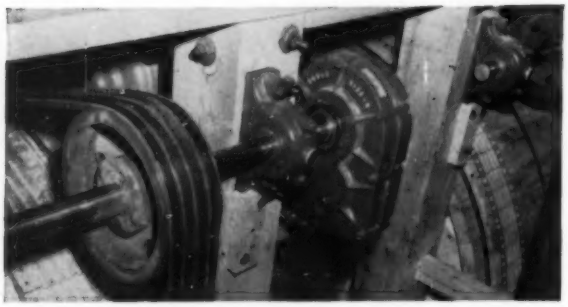
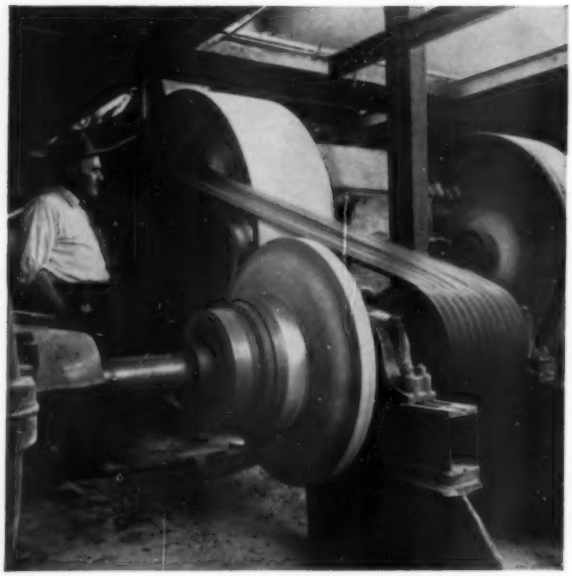
Nike Zeus underground launch

Authors in this issue: George Fielding Eliot • Vern Haugland • Brig. Gen. A. W. Betts • M. R. Warden • Jac Weller • Hoffman Nickerson • Rear Adm. John D. Hayes • H. B. Porter • S. H. Herzog • Spence T. Marks • Kenneth A. Johnson • Errol J. Gay • Also a new department on Underwater Ordnance

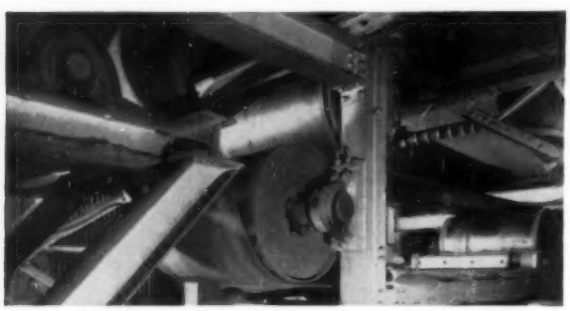
How Dodge pillow blocks with Timken® bearings give longer life with less maintenance



1. Two 2 7/16" Dodge Special Duty pillow blocks equipped with Timken® tapered roller bearings, support the line shaft driving six by eight foot tanning drums. The tapered design of Timken bearings enables them to take both radial and thrust loads in any combination.



2. The crusher at a trap rock and asphalt plant runs faster, gives more production now that Dodge Double Interlock pillow blocks on Timken bearings are installed. The Timken bearings in these blocks give full-line contact between rollers and races for greater load carrying capacity.



3. The Timken bearings in All-Steel Dodge pillow blocks must stand up under adverse operating conditions found when sintering metals. One major advantage of Timken tapered roller bearings is their ability to hold housings and shafts concentric, thus keeping lubricant in, dirt and dust out.

The photo at right shows the Dodge All-Steel pillow block Timken bearing equipped. The specially designed bearing has a tapered bore with self-aligning spherical outer surface—never needs adjustment.

There's a Dodge pillow block equipped with Timken bearings to fill every engineering need: All-Steel, Type "E", Double-Interlock, Type "C" and Special Duty. And with Timken bearings, space consuming thrust devices are not needed. Look for Timken bearings in all the machines you buy or build. They're the symbol of quality. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ont.

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VOL. XLV NOVEMBER-DECEMBER 1960 NO. 243

The Cover.—The Army's Nike Zeus antimissile missile is shown leaving its new underground launcher at the White Sands Missile Range for the first time. Recently disclosed underground cells make the missile resistant to enemy attack (Army photo).

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THE CONTENTS OF THIS ISSUE IN BRIEF

Our Troops Must Be Ready (p. 336) . . . . "Power pursued over a period of time will build up a climate of public confidence which will be apparent throughout the world," Maj. George Fielding Eliot writes, as he unfolds the story of the importance of the American foot soldier—the physical, visible, and spiritual symbol of confidence for people of other lands.

Nuclear Flight Nears (p. 340) . . . . A new craft to serve our sky needs will appear in the wild blue yonder by 1965, according to Associated Press writer Vern Haugland. This plane will not be the enormous one once planned, but its endurance and ability to stay aloft for long periods of time without the fuel penalties imposed on more conventional aircraft should put this ship way ahead in the skies of tomorrow.

Stop That Missile! (p. 344) . . . As a nonaggressor nation, a strong defense is the best hope we have of being able to destroy enemy attack capability, according to Brig. Gen. A. W. Betts, Director, Advanced Research Projects Agency. He says a concentrated effort to develop a ballistic-missile defense should be made but warns that we must put as much effort into this as we did into our ICBM research.

Arsenals Are Essential (p. 349) . . . . A cooperative combination of industry and Government will aid the small-arms ammunition problem. In the area of research, development, and engineering there is no real competition, author Maxwell R. Warden tells us. Government arsenals, therefore, are really the answer for they can "ride herd" on problems of either industry or Government.

The West German Army (p. 351) . . . . To maintain might to prevent a fight is the philosophy developed by the West German Army, which is leaning hard on the experience and know-how of the veterans of World War II but is carefully sidestepping the mistakes made in that conflict. There is a brand-new organization of fully mechanized Bundeswher battalions ready to fight, if necessary, either in a conventional or atomic war, according to author Jac Weller's informative article.

Atomic Age Warfare (p. 355) . . . . The "sky is not the limit" on taxation, for we could tax ourselves right into socialism, Hoffman Nickerson, famed military expert and author warns as he critically analyzes Oskar Morgenstern's book, "The Question of National Defense." This critic eloquently praises Mr. Morgenstern's com-

ments on providing more nuclear-powered submarines and missiles, but cautions that we must be cost-conscious.

Fleet against Fort (p. 357) . . . . Military genius pitted against seapower were the great strategic forces during the Civil War. Rear Adm. John D. Hayes, U.S.N. (Ret.), gives this particularly vivid account of the Battle of Drewry's Bluff, just below Richmond, Va., where a hastily erected 5-gun Confederate battery fought against two ironclad ships with significant results for both sides.

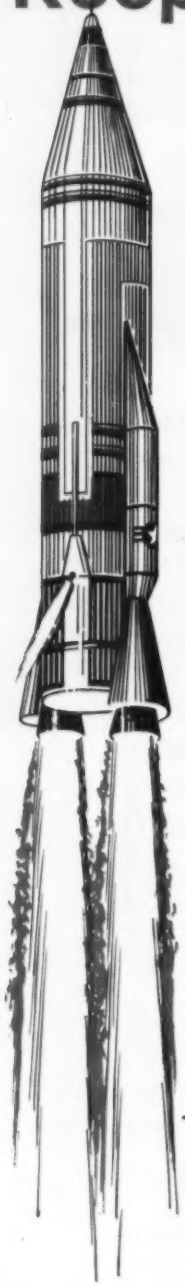
Materials Make Missiles (p. 431) . . . . Semantics in the field of modern rocketry is discussed by two U. S. Naval Ordnance Test Station engineers of China Lake, Calif. These specialists, H. B. Porter and S. H. Herzog, explore the concepts of high temperatures in rockets and state that research and development demand continuity. The development of a system of nomenclature is essential to the dissemination of information and the cross-fertilization of ideas.

What's Up There? (p. 434) . . . . Rocket research soars into the upper atmosphere at Aberdeen Proving Ground, Md., as physicist Spence T. Marks launches into a vivid description of what has occurred during the International Geophysical Year. During the experiments, fifteen upper-air rockets and eleven balloon flights were evaluated.

Rocket Thrust Control (p. 438) . . . . The success of missile and space-vehicle endeavors is largely dependent upon the accurate control of solid-propellant rockets, Kenneth A. Johnson believes. He gives a concise report of the techniques involved in the development of an exploding bridgewire system to terminate rocket thrust and summarizes the advantages it offers to missile designers.

Vehicle Reliability (p. 441) . . . .A consulting engineer gives his views on objectives for attaining reliability in combat and tactical military vehicles. Errol J. Gay, of Detroit, Mich., says that the military and industry must realize that off-the-shelf vehicles do not fit military needs *per se*. However, minor redesign of such equipment often will make it suitable for military use.

Keep America ON THE TARGET



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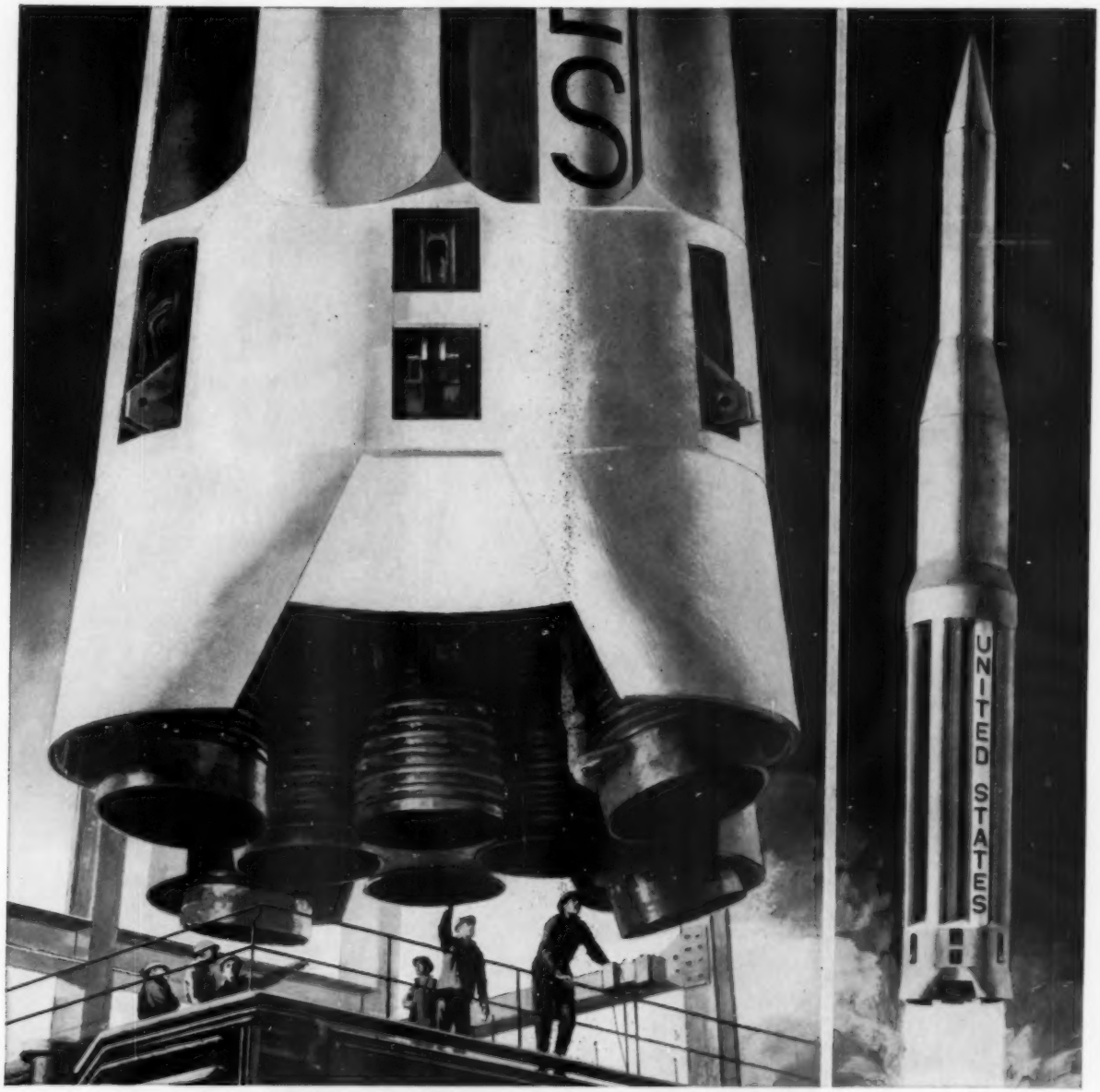

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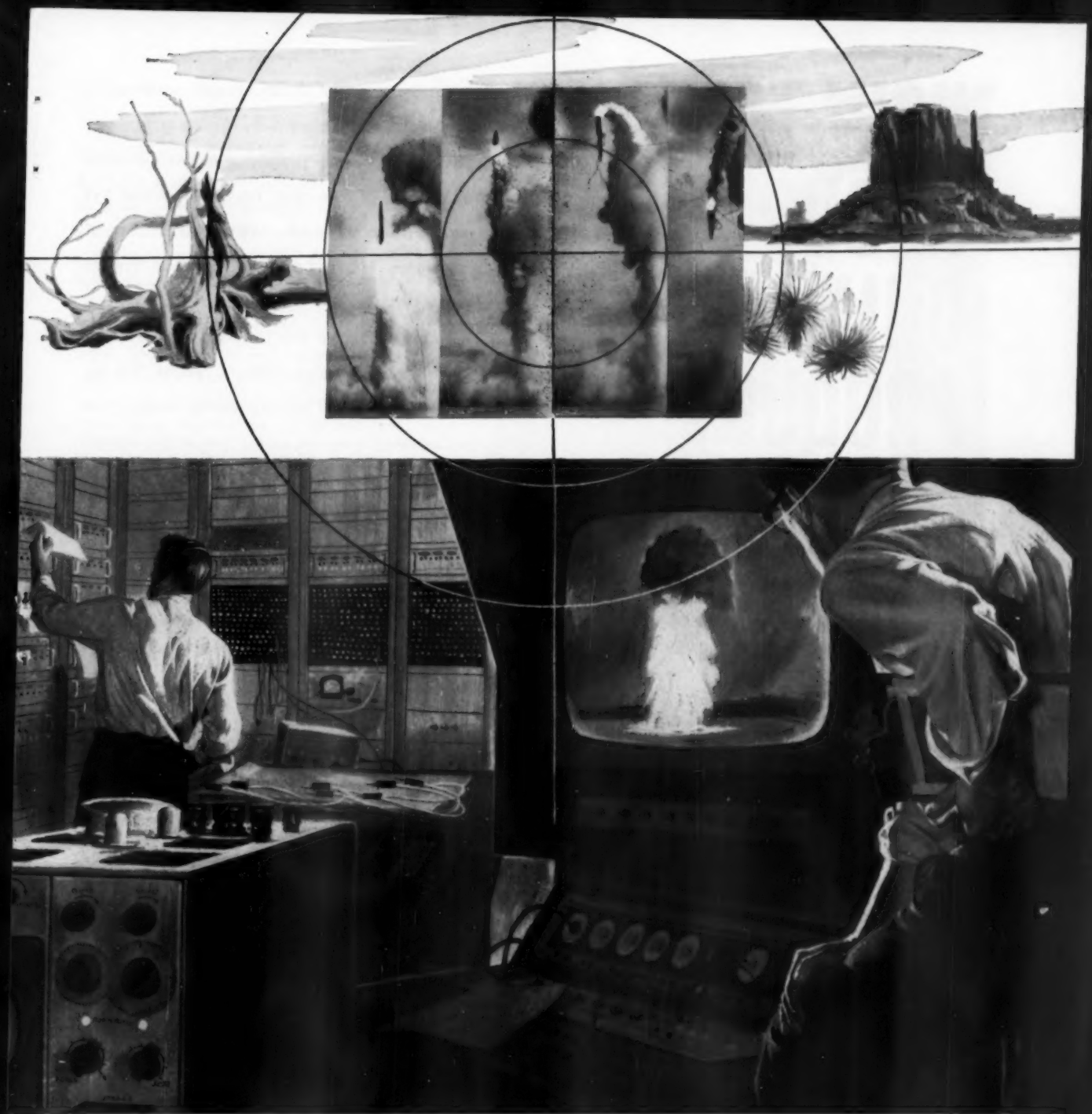

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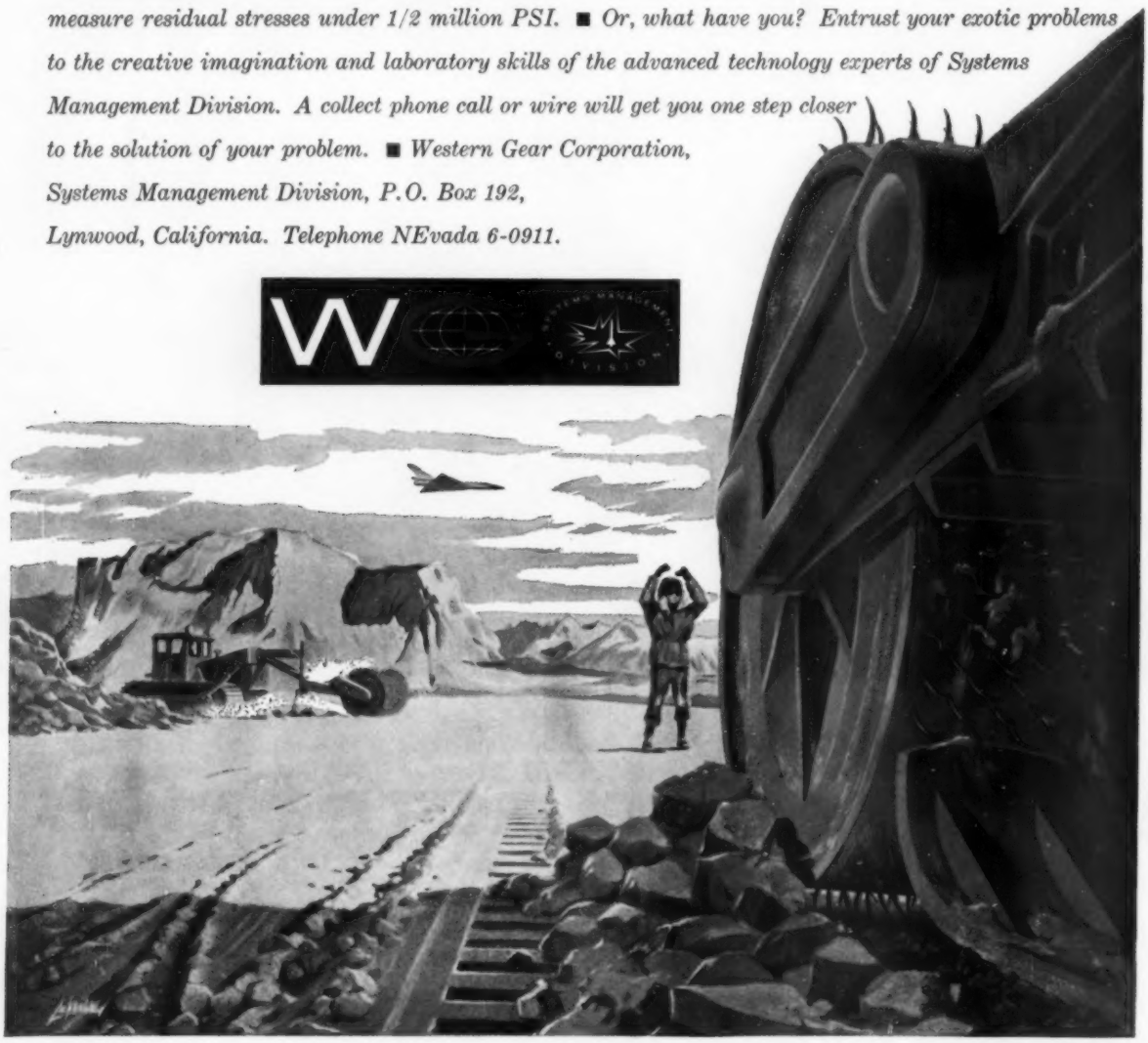

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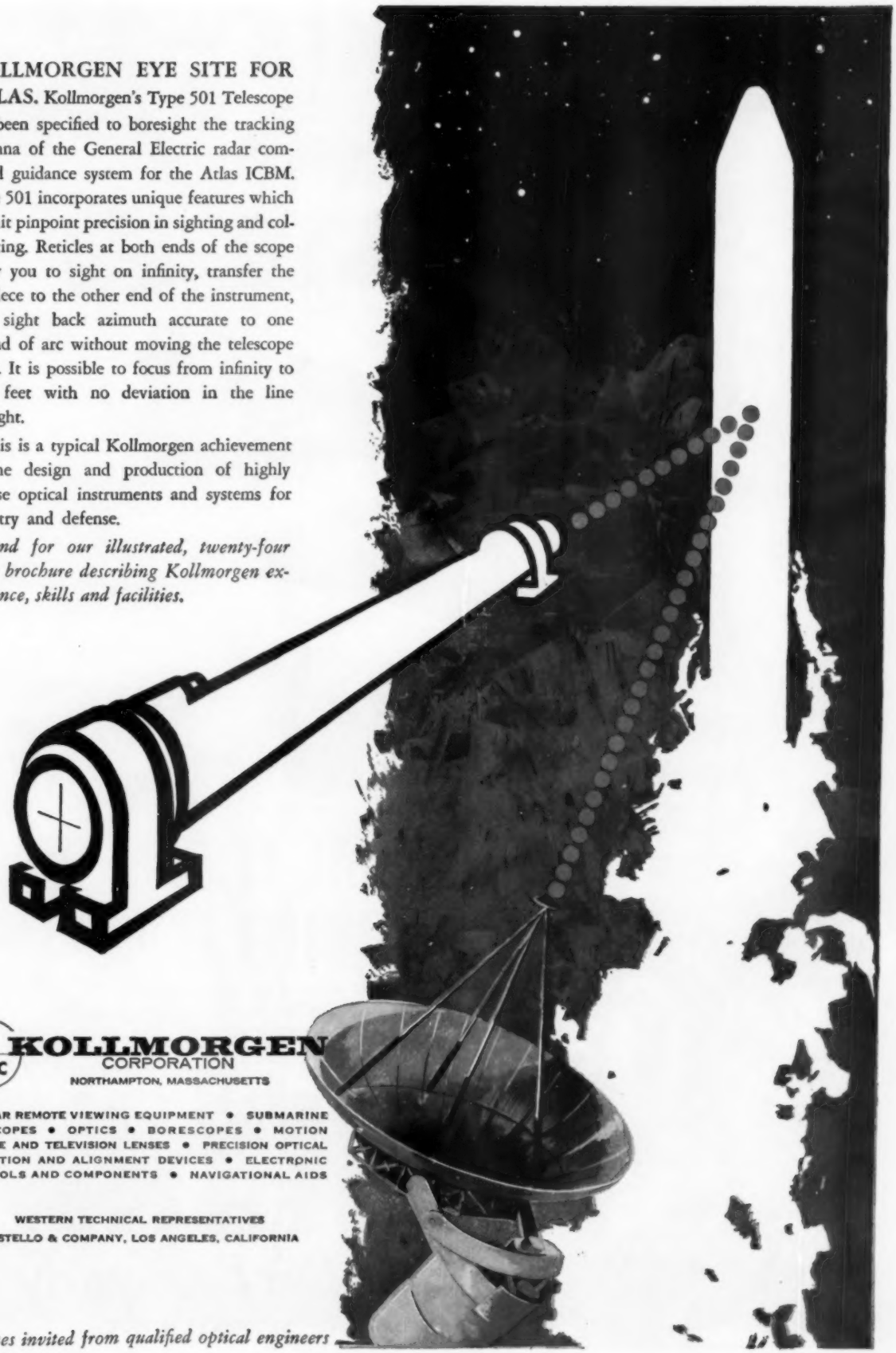

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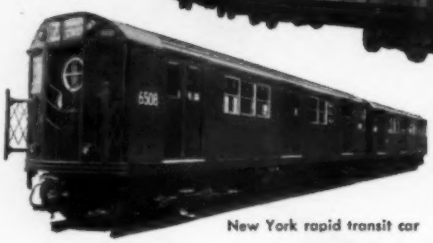

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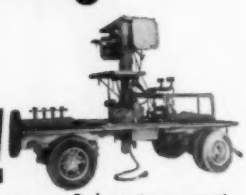

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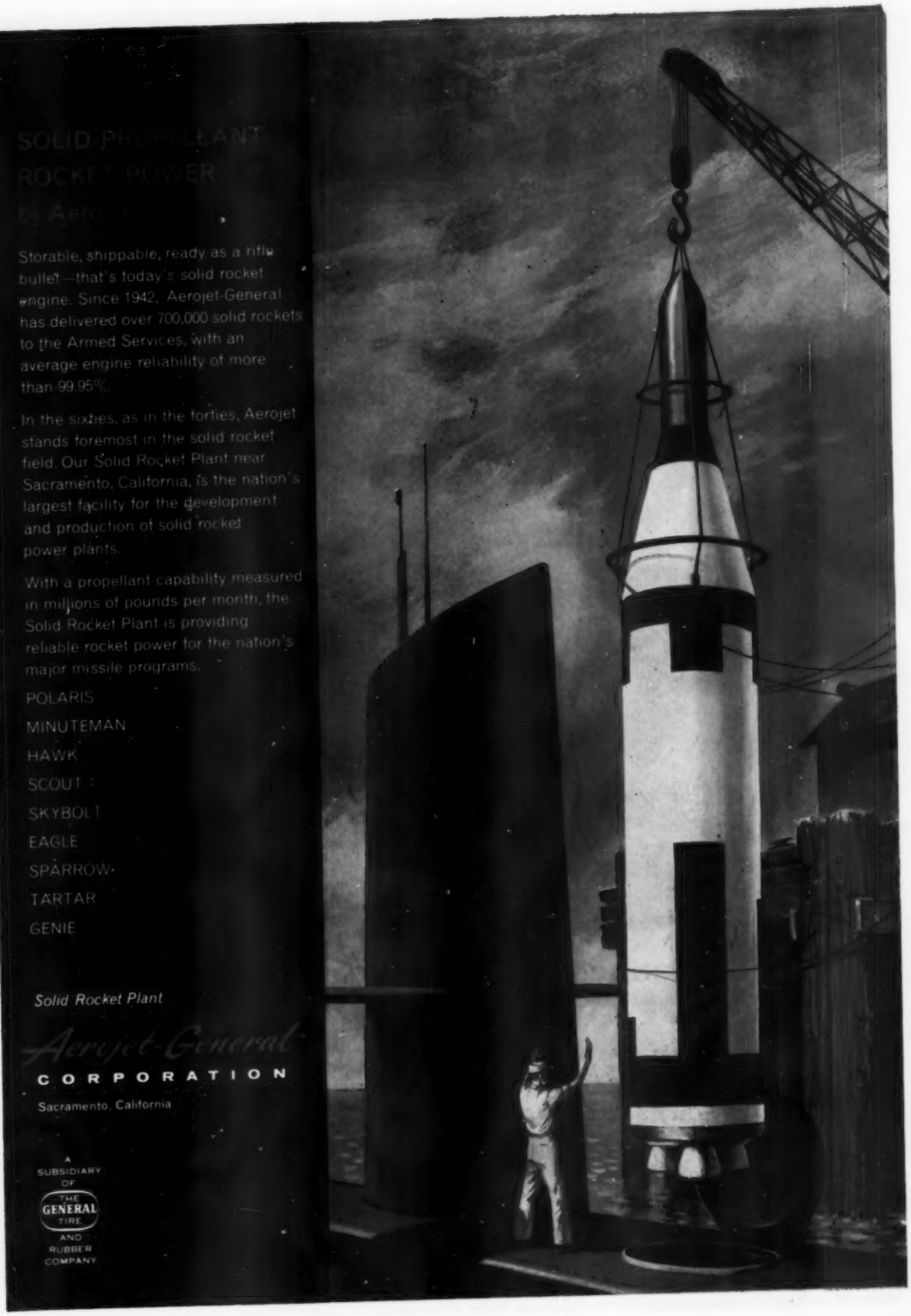
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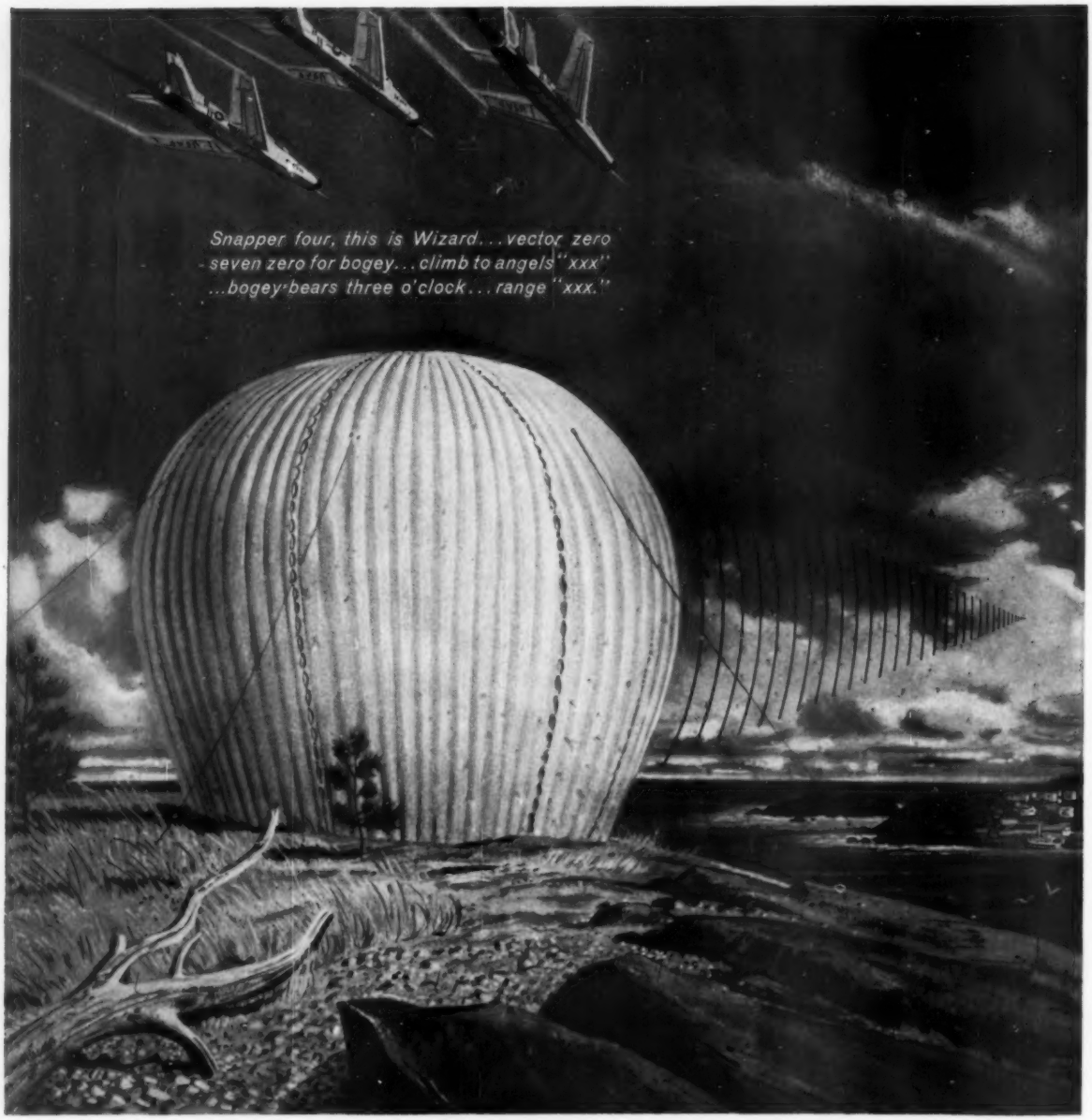

For the U.S. Marines—ASSIGNMENT INTERCEPT

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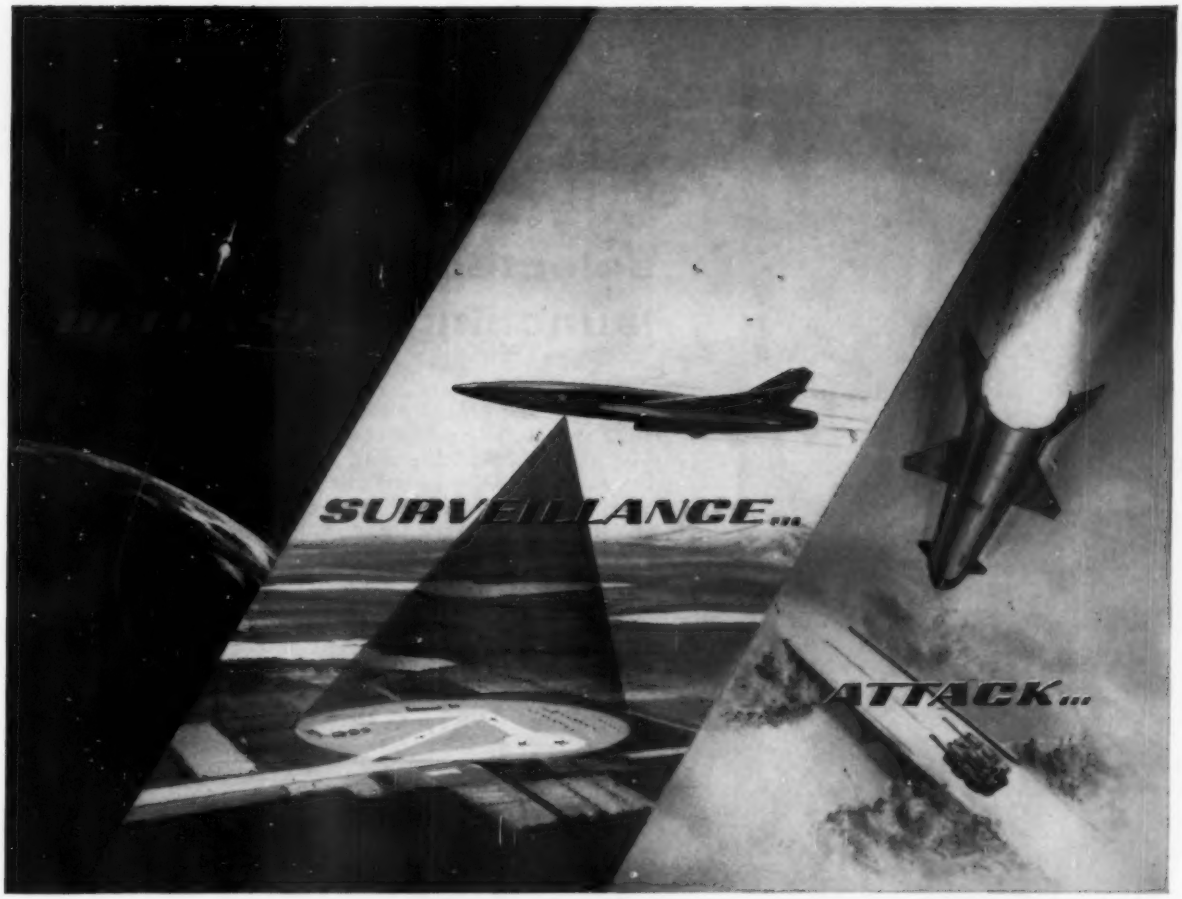

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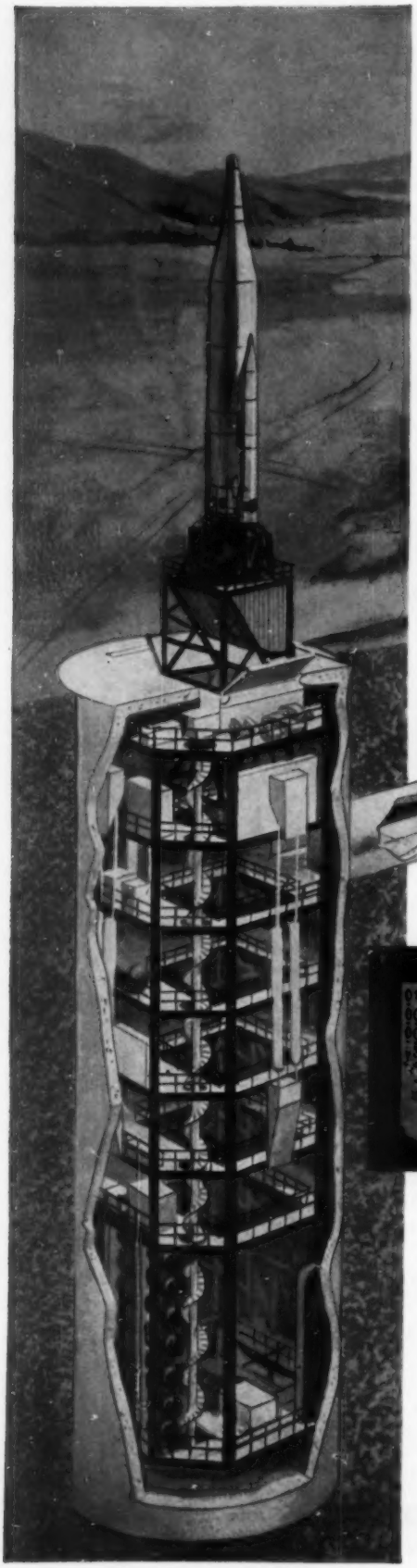

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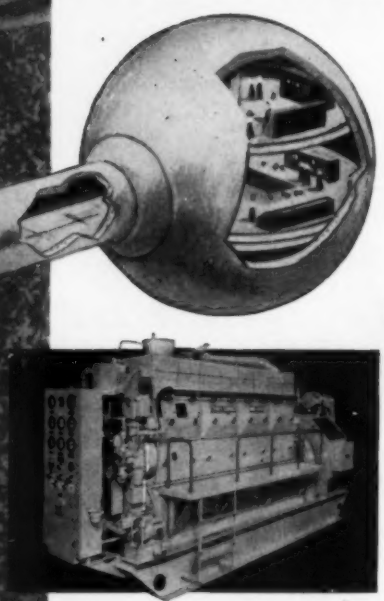

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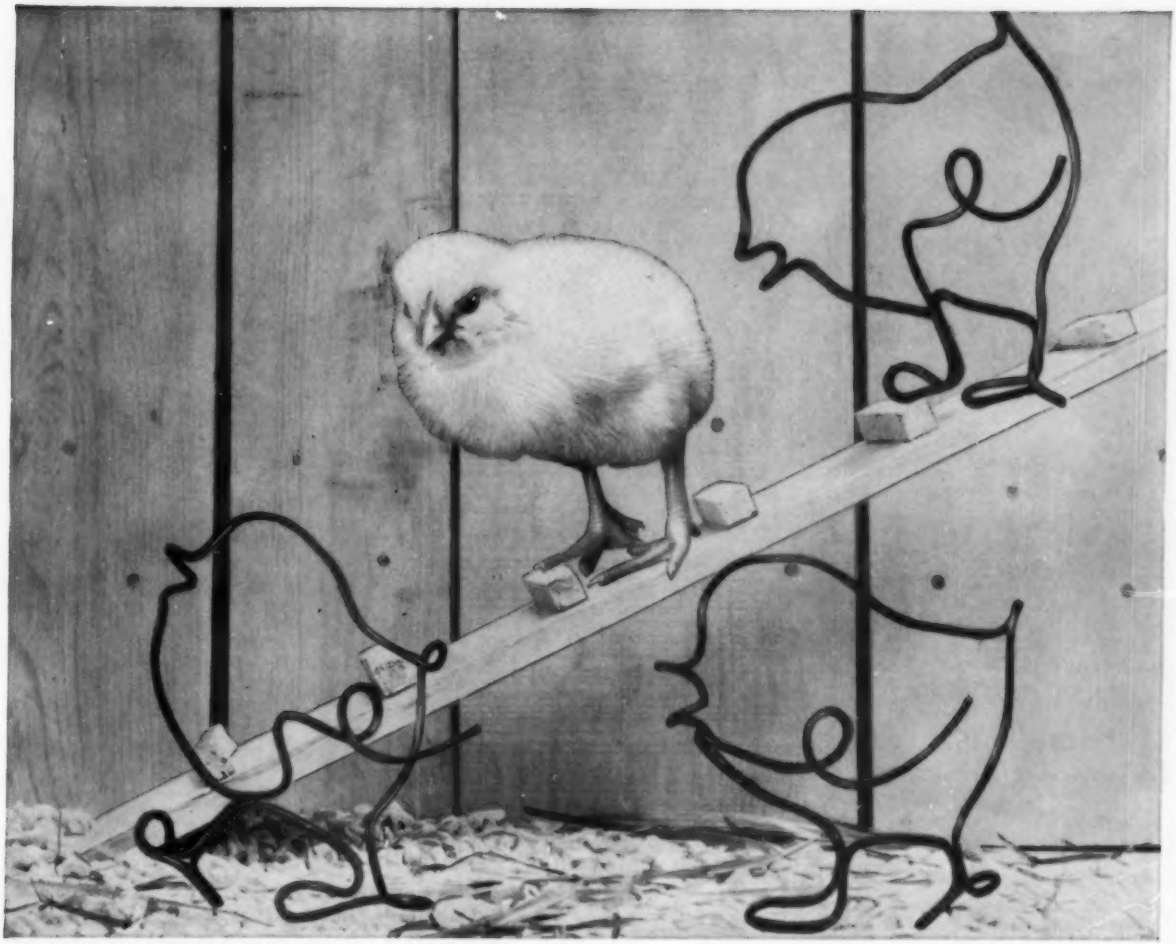
The contract for 149 Superiors highlights a growing and impressive list of Superior-powered U.S. defense installations. Included are the "Texas Towers," portions of "DEW" line and "SAGE" project, Eglin Gulf Test Range and other missile tracking ranges, and numerous launching sites for other types of missiles. Acceptance of Superior engines for these assignments is convincing evidence of their rugged dependability, trouble-free performance and economical fuel consumption. Superior engines—215 to 2150 HP or 150 to 1500 KW—will also meet your exact power requirements, including automatic, unattended or remote controlled operation. Write for complete information today!

USAF artist's conception of Atlas underground silo for launching missiles



Bundy can mass-fabricate practically anything

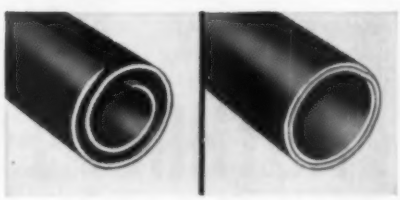
Bundyweld®—the original double-walled steel tubing—is ideal for everything from simple bends to complex shapes

The old adage, "Don't count your chickens before they hatch," is a good one . . . but it rarely applies to Bundy. That's because, no matter how complex your tubing problem, you *can* count on Bundy for the perfect solution.

Bundy engineers and designers are backed by years of experience in the mass-fabrication of steel tubing. And they are available to you at any stage of product development for time- and money-saving suggestions. Their key: Bundyweld®!

Bundyweld steel tubing is double-walled, copper-brazed, stronger, with higher bursting and fatigue strengths. That makes Bundyweld the safety standard in small-diameter tubing—and a wise choice for a wide variety of tubing applications! Meets ASTM-254 and Government Spec. MIL-T-3520, Type III.

So, when you want to talk tubing, talk to the leader—Bundy! Phone, write, or wire Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld is the original tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

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Modern concepts of battlefield tactics require a high degree of ground mobility for many new weapon systems. Whatever the requirement – missile transporter launchers – radar or communication equipment – ground support equipment – cargo vans – troop transport – all can have full mobility with one or more standard military vehicles of the new M113 family.

This family of vehicles in either armored or unarmored versions is lightweight to be airborne, amphibious to swim water barriers, tough and dependable for continuous heavy duty.

Test data is available on request concerning the shock loads transmitted to missile systems being carried under the most severe cross-country conditions.

Put your mobility questions to FMC, since 1941 a leading designer and builder of military standard vehicles.

For further information, write on company letterhead to Preliminary Design Engineering Dept., FMC Ordnance Division, P.O. Box 367, San Jose, Calif. Phone CYpress 4-8124.

Putting Ideas to Work

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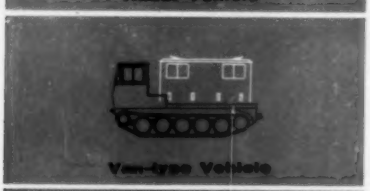
Illustrated below are the M113 and five vehicle adaptations of this basic tracked vehicle. All of the vehicles use the same military standard equipment, including engines, power train, and suspension components; thus reducing the military logistic burden and R&D costs in weapons systems.



FMC's Aluminum Alloy Welding Techniques Open New Horizons for Structural Applications

Machine welding heavy aluminum armor plate in FMC's Ordnance Division's shops.

Food Machinery and Chemical Corporation's recently developed welding techniques make economical heavy aluminum weldments possible. High strength, low weight, gas and liquid tight construction are a few of the characteristics available through modern welded aluminum fabrication. These techniques are ideally suited to the construction of vehicles – landing craft, barges, containers – on an economically sound basis.

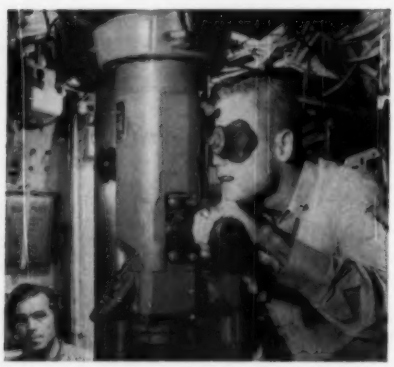
FMC's aluminum welding capabilities are the result of extensive research and development work performed in cooperation with military agencies to develop reliable, economical welding techniques for the production of the aluminum M113 Armored Personnel Carrier. Thousands of pounds of various aluminum alloys were formed, welded, machined and tested to select the best alloys and fabrication methods. Over a score of prototype M113's were then constructed and subsequently tested by military agencies to substantiate the vehicle's design and construction.

The economy realized through FMC's development of welding and fabrication techniques is an important factor... making the cost of the aluminum M113 competitive with the M59, its steel predecessor. Welding costs for this all aluminum vehicle were reduced through the use of –

Optimum joint geometry
Maximum use of welding fixtures
Maximum use of automatic plate preparation equipment
Maximum use of machine welding equipment
Maximum use of extruded shapes

These modern methods and facilities may provide the answer to your problems in procuring high performance equipment.

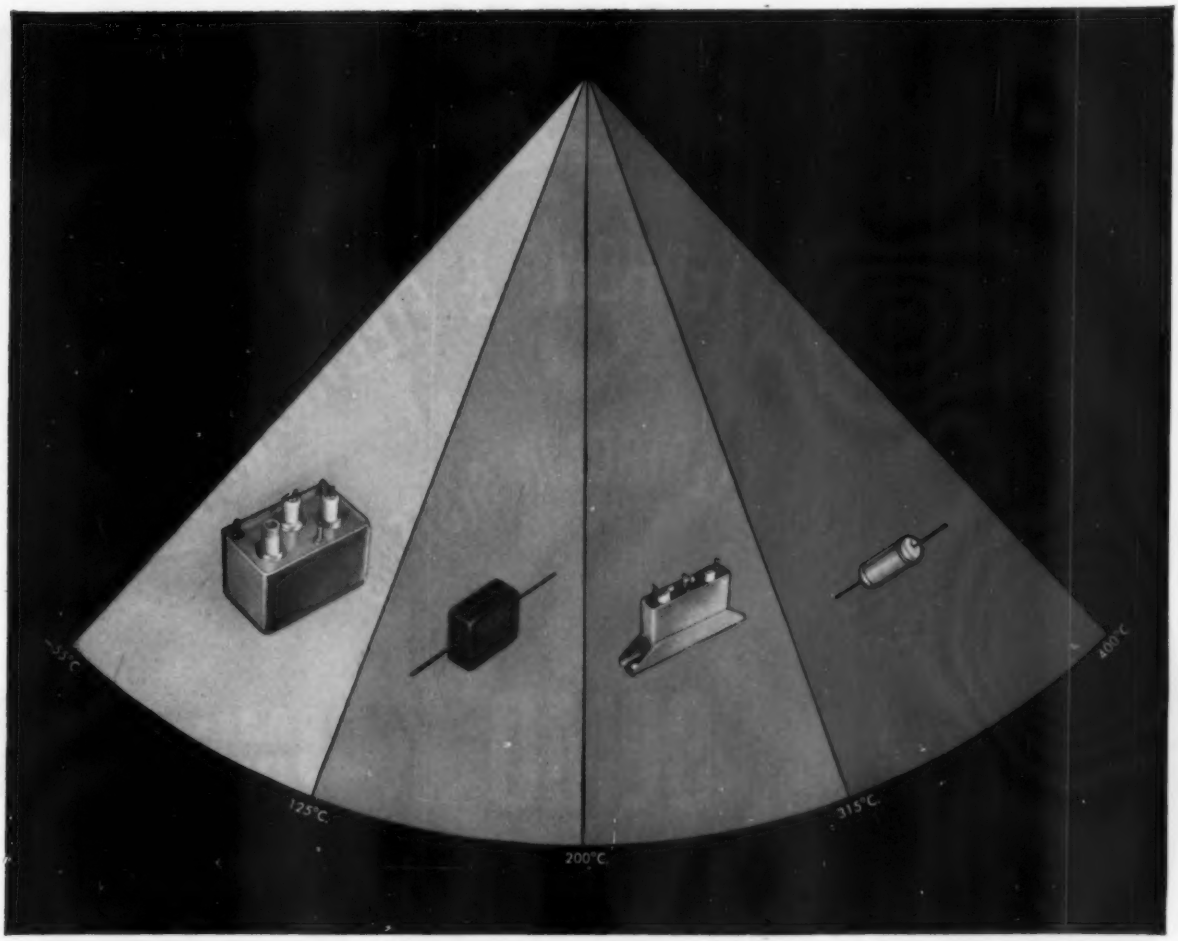
The new aluminum welding techniques developed for the M113 program and vehicle production, illustrates FMC's fully integrated capabilities and facilities.



Teamwork: the best anti-submarine weapon

In the air, on the surface and under water, they work together. *Teamwork,* itself, becomes a science in hunting down a sub. Technically advanced equipment — teamed up with deadly precision — is being designed to leave enemy subs no escape. This future is taking shape now in broad studies at Vought Aeronautics. Aircraft, developed especially for most efficient use of electronic search equipment . . . advanced sonobuoys . . . even space systems, under study by Vought Astronautics. These and other ideas are undergoing analysis, or actual test in Navy ships and planes. By drawing on the broad resources of its sister divisions, Vought Aeronautics, like the Fleet, is using teamwork to serve the Navy's Number One Mission.

CHANCE VOUGHT AERONAUTICS DIVISION DALLAS, TEXAS



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315°C. to 400°C.—In development
• .001 to 6.0 uf, 150 V and 600 V • Drift—5% capacitance change typical from −55°C. to +426°C. • High I. R.—1 megohm X microfarad typical at 400°C. • Prototype availability • Only inorganic materials used.

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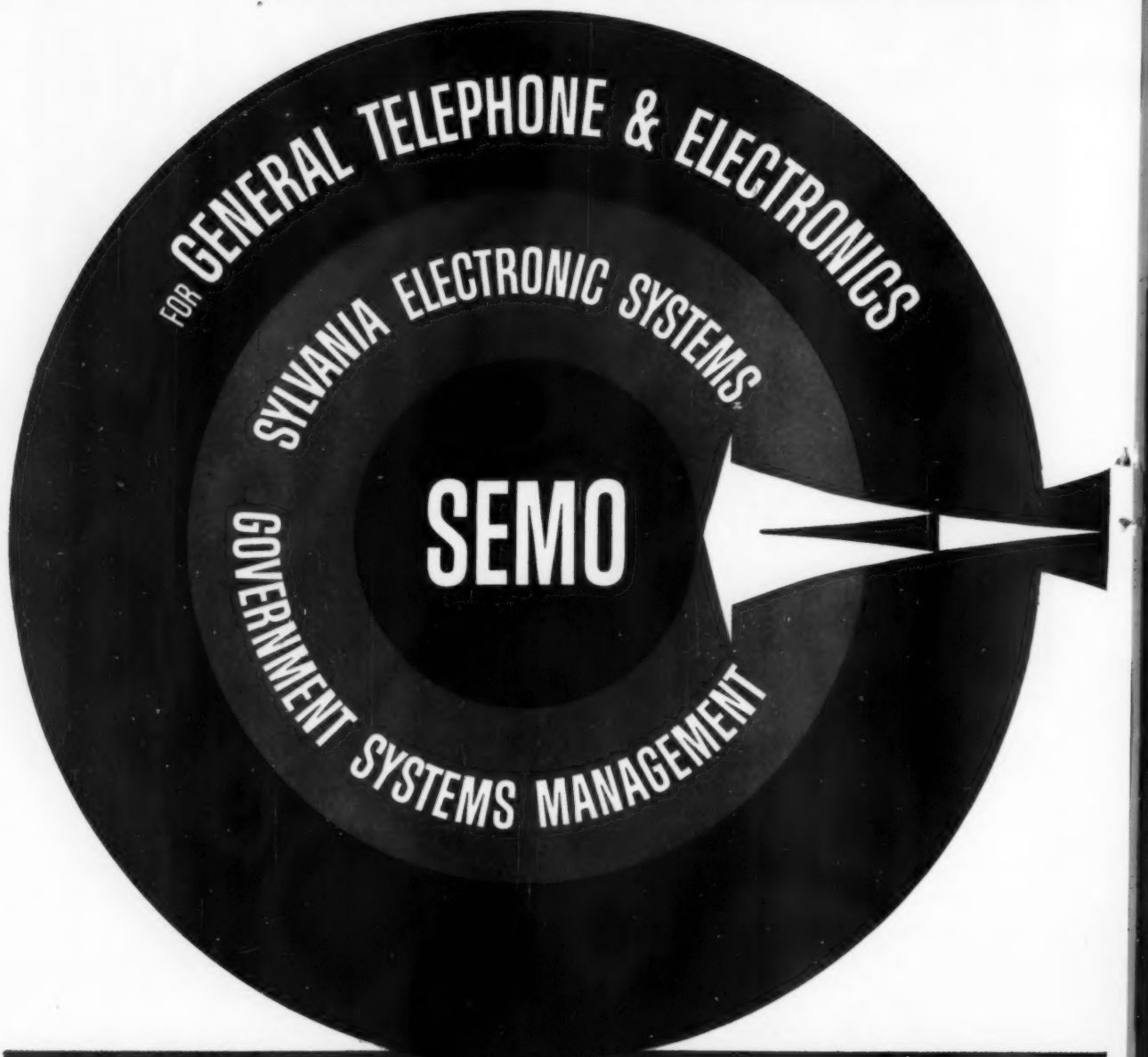

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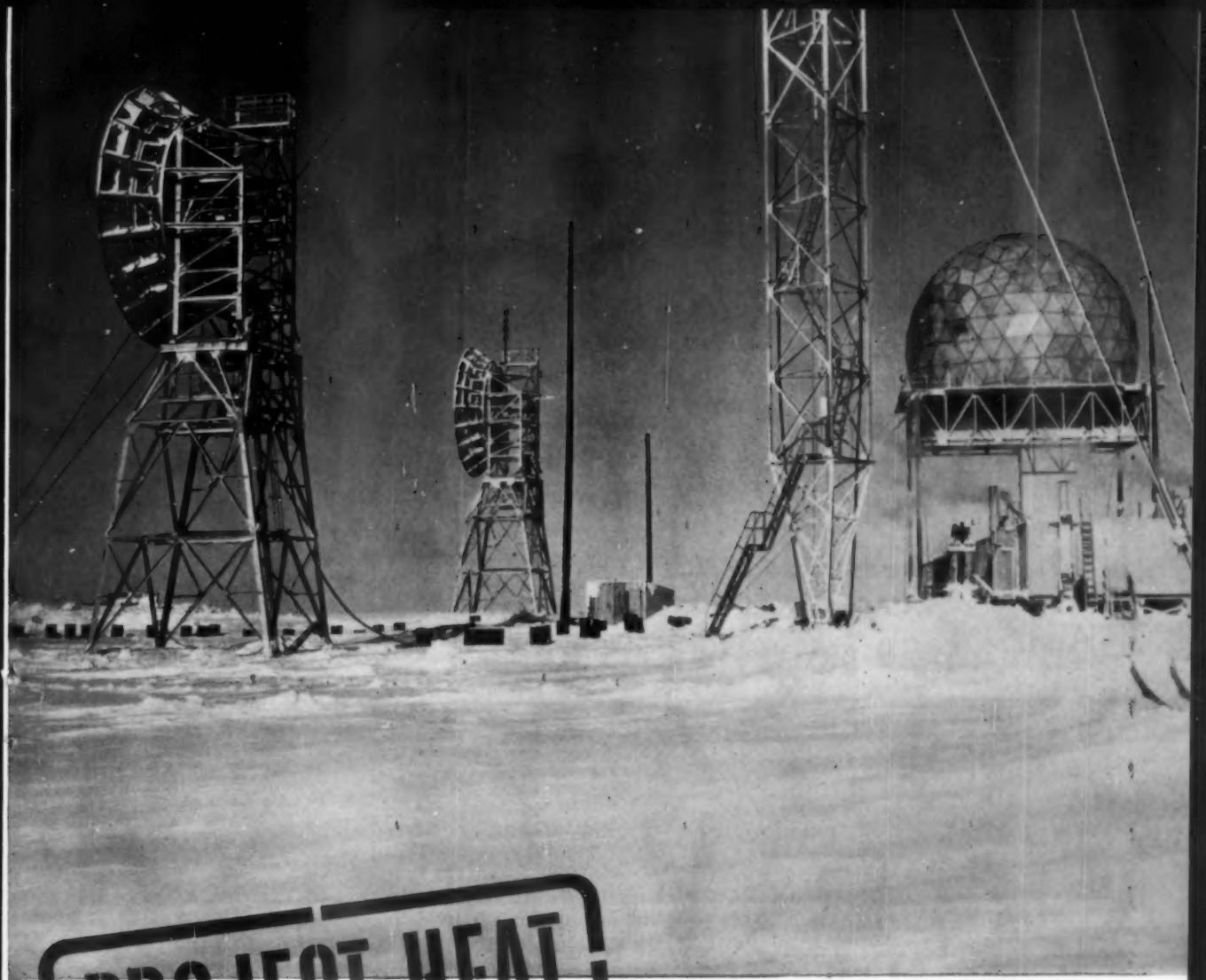

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Hunter heating systems with *sealed-in-steel* combustion are employed for a wide variety of military uses—for space and personnel heating in mobile shelters, in portable or fixed structures of many different types, in self-propelled vehicles, in ground support systems for missiles, in radar and microwave systems, etc.

Other types of Hunter systems are widely used in winterization operations, for engine pre-heating, for emergency heating requirements and for many other using arm operations. Hunter heating systems are designed for cold starts down to 65° below zero and are air-circulating in type with thermostatic controls. Uncontaminated heat capacities range from 15,000 to 300,000 BTU/hour.

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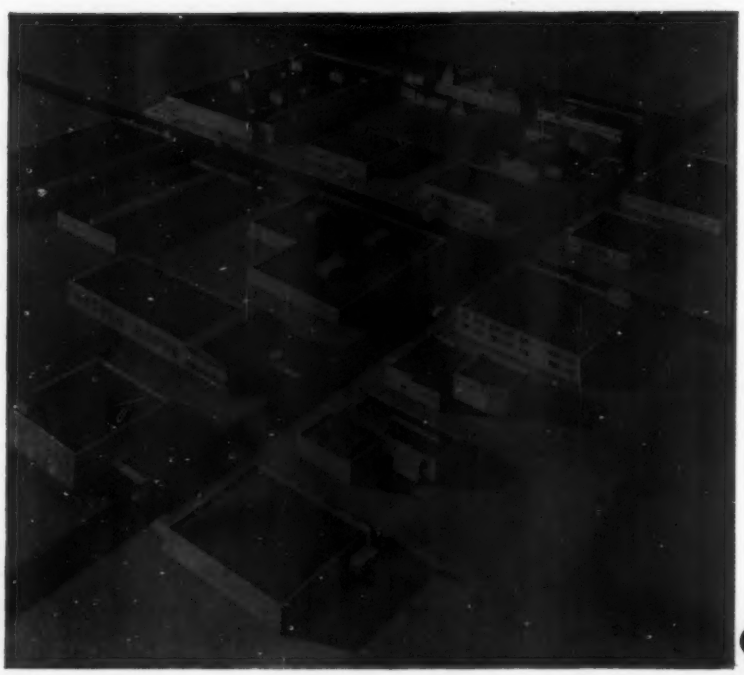
Shown below is a composite view of Librascope's facilities where a variety of computer systems are currently in different stages of design and production. Some are strategically involved with national defense...others deal with business and industrial process control. Each is uniquely designed to answer a particular need. The success of these systems illustrates the value of Librascope's engineering philosophy: A decentralized organization of specialized project teams responsible for assignments from concept to delivery...and backed up by excellent research, service, and production facilities. For your computer requirements, call on the company whose breadth of diversification in computer technology is unsurpassed. ■ Librascope Division, General Precision, Inc., 808 Western Avenue, Glendale, Calif. For career opportunities write to John Schmidt, Engineering Employment. ■

computers that pace man's expanding mind



ATOMIC ENERGY

Exposure Limits Lowered

The Atomic Energy Commission has revised its regulations for the protection of employees in atomic-energy industries and the general public against hazards arising out of the possession or use of AEC-licensed radioactive materials.

The revisions are embodied in amendments to Title 10, Chapter 1, Part 20, of the Code of Federal Regulations entitled "Standards for Protection against Radiation." The amendments become effective on January 1, 1961.

The principal effect of the amendments will be to limit the lifetime accumulated dose of radiation workers to approximately one-third the limits permitted under the regulation as it now stands. The amendments will limit the total external radiation exposure that any worker may accumulate beyond the age of eighteen to an average of five rems per year and to not more than three rems in any one quarter. The present limit for radiation workers is approximately fifteen rems a year without further restrictions as to accumulated dose.

A rem (roentgen equivalent man) is a radiation dose of any ionizing radiation estimated to produce a biological effect equivalent to that produced by one roentgen of X-rays.

Radiation limits as set in the regulations are not to be regarded as absolute limits below which no hazard from radiation exists and above which an individual automatically receives a dangerous dose of radiation.

Experimental Facility

The Atomics International Division of North American Aviation, Inc., will construct a critical-experiments facility at its field-test area in Ventura County, Calif.

A critical-experiments facility is a reactor in which the arrangements of the fuel assembly and other components are not permanent but are capable of quick and easy change for the study of the behavior of fissionable materials at various degrees of enrichment and in different shapes.

Atomics International is under contract to Southwest Atomic Associates of Shreveport, La., to investigate the economic possibilities of an advanced epithermal thorium reactor for electric power production. Nuclear data for the design and evaluation of such a reactor, however, are limited, and Atomics International has built the critical facility to investigate the

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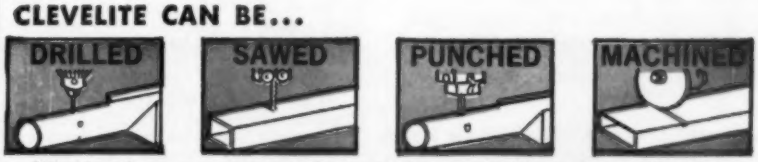

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characteristics and nuclear properties of epithermal neutron energy systems.

The critical facility is a separable-half type of assembly in which core materials are loaded into drawers which are inserted into aluminum matrices mounted on the two halves of the machine. Power levels will not exceed 200 thermal watts.

New Power Plant

The Yankee Atomic Electric Company's 134,000-electrical-kilowatt nuclear power plant near Rowe, Mass., which achieved criticality in August, is expected to operate at full power later this year. The plant, which has a pressurized-water reactor, is the first to be completed under the AEC's Power Demonstration Reactor Program.

Operation of the Yankee plant is expected to provide important technical and economic data which will advance the time when economic nuclear power becomes a reality. Design was begun in June 1956. Construction was started in November 1957 and was completed on schedule on July 7, 1960.

The prime contractors to the Yankee Atomic Electric Company for the research, development, design, and construction of this plant were the Westinghouse Electric Corporation, Pittsburgh, Pa., and Stone & Webster Engineering Corporation, Boston, Mass.

The Commission initiated its Power Demonstration Reactor Program in January 1955. Under this program, authorized by Congress, the Commission provides limited assistance for research and development and waives fuel-use charges for industrial reactor projects that help to advance nuclear-power technology and accelerate the development of commercial power reactors. In addition to the Yankee plant, the first to be completed under the demonstration program, the Commission has negotiated contracts with similar demonstration program arrangements for the following nuclear power plants:

Hallam Nuclear Power Facility, Hallam, Nebr.; Enrico Fermi Atomic Power Plant, Lagoona Beach, Mich.; Rural Cooperative Power Association Reactor, Elk River, Minn.; City of Piqua Reactor, Piqua, Ohio; Puerto Rico Water Resources Authority Reactor, Punta Higuera, Puerto Rico; Pathfinder Atomic Power Plant, Sioux Falls, S. D.; East Central and Florida West Coast Nuclear Groups Reactor, Pierce, Fla.; Carolinas Virginia Reactor, Parr, S. C.; Philadelphia Electric Company Reactor, Peach Bottom, Pa.

Gas-Cooled Reactor

The Atomic Energy Commission's development of a mobile nuclear power plant for the Army passed a major test when the Gas Cooled Reactor Experiment achieved full-power operation at

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For instance, ALRI: USAF Airborne Long Range Input Program, one more demonstration of Computence—and Burroughs Corporation—throughout the contract team program. **The objective:** a seaward, airborne extension of SAGE via radar-equipped reconnaissance aircraft, processing data in flight and transmitting it through ground receiving sites to central direction centers. **Total competence:** the way Burroughs Corporation, as System Manager, directs the integration of the special skills and facilities of its team*. **Total computence:** the way Burroughs Corporation, also a team member, develops ALRI's miniaturized airborne data processors—reflections of its breadth (R & D through field service), brains (such as the Atlas guidance computers, data processing for Polaris) and background (75 years devoted to computation and data processing).

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Pulses intercepted by the parabolic reflector are directed into the waveguide assembly, where they are phase-modulated (and to a small degree amplitude-modulated) by bias switching diodes. Switching frequency can be adjusted over a ratio of approximately 2 to 1, depending upon voltage of battery used.

Unique applications in L-band or other frequency bands as a research tool for the investigation of propagation paths or for commercial uses also available.

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Atomic Energy (Contd.)

the National Reactor Testing Station in Idaho.

Successful full-power operation of the GCRE-I marks an important milestone in the development of the first U. S. direct- and closed-cycle gas-cooled nuclear power plant. In such a system the gas, heated in the reactor core, is used to drive a turbine and is then recycled to the reactor. The turbine is coupled to the electrical-generation system. This unique system has been under development for nearly five years.

The GCRE-I is part of an over-all research and development program being conducted by Aerojet-General Corporation under contract to the Atomic Energy Commission and the U. S. Army Corps of Engineers to provide a mobile nuclear power plant for the Department of Defense. Operation of a prototype of this power plant, which will be known as the Mobile Low-Power Nuclear Power Plant No. 1 (ML-1), is scheduled for next year.

The ML-1, transportable in four packages totaling less than thirty-eight tons, combines the gas-cooled reactor system with a direct- and closed-cycle gas-turbine-driven power-conversion system. The plant will generate about 300 net kilowatts of electricity and when fully developed will operate at least one year at full power without refueling. The power plant is designed to be operable twelve hours after delivery at a site. Adequate shielding will permit relocation twenty-four hours after shutdown.

New Core Tested

An experimental nuclear core designed for use in a compact reactor which would generate electricity directly without moving parts has been tested successfully. The core is only 7 inches high, 7 inches in diameter, one-fifth of a cubic foot in volume and weighs less than 200 pounds.

The experimental core was designed and constructed for the AEC by Atomics International, a division of North American Aviation, Inc., Canoga Park, Calif., as part of a Commission program to develop systems for nuclear auxiliary power (SNAP) for space vehicles. The experiment is located at a Commission facility operated by the company in the Santa Susana mountains twenty-five miles north of Los Angeles.

The purpose of the experiment is to obtain physics data for the development of a complete reactor system. No electricity is being generated. The complete system, including a thermoelectric conversion device, is scheduled to be tested early next year. It has been designated SNAP 10.

The fuel and moderator in the experimental device is a homogeneous mixture of uranium 235 and zirconium hydride. The heat-conduction and reflector units are made of beryllium. The device is divided into two identical units which were

STRUCTURAL INTEGRITY OF SOLID PROPELLANT GRAINS

The demand for ever larger rocket motors, coupled with the importance of mobility, fast countdown and low cost, steadily increases the importance of solid propellant rockets. To extend the state-of-the-art, Grand Central Rocket Co. has accelerated an important research project on the amount and cause of physical deformation or propellant "slump" in very large solid propellant motors.

Because the solid propellant is essentially a rubbery, visco-elastic material, it may be deformed—like rubber—by a combination of force and time. Its behavior is strongly dependent on the conditions of deformation and is particularly "rate" sensitive. Under extreme conditions this deformation can cause failures.

The studies by Grand Central Rocket's research team will attempt to establish criteria for the amount of deformation of various solid propellant materials under various combinations of time and force, such as during ignition (short time, large force); in flight (less force, longer time); or during storage (thermal cycling and gravity forces, for a long time).

From the research being conducted, engineers will be able to design large solid propellant motors which have known values of structural integrity—and resultant operational reliability.

Grand Central Rocket scientists and engineers are developing design criteria based on non-linear visco-elastic theory—a basic step necessary before very large missile motors may be designed with high certainty of reliability.

The project is another demonstration of Grand Central Rocket's unique capability to handle difficult assignments in the field of rocket motor and propellant research—a capability assured by one of the nation's finest rocket research and design teams.

Positions open for chemists, engineers and solid rocket production specialists.

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brought together by remote control to achieve a sustained chain reaction. Each half was built up with alternate layers of fuel-moderator disks and circular conduction plates within a reflector.

In the complete SNAP 10 system, thermocouples will surround the reactor core. Electricity will be generated by the flow of heat from the reactor through the thermocouples. Excess heat, not used in the generation of the electricity, will flow through the thermocouples and then to radiator fins.

Packaged Power Plant

The AEC has selected, as a basis for contract negotiations, a proposal of the Martin Company, Baltimore, Md., to supply a packaged nuclear power plant for McMurdo Sound in Antarctica at a fixed price of not more than $3,950,678. This is the first of several plants authorized for installation in the Antarctic.

Under the terms of the contract, the Martin Company will design a 1,500-electric-kilowatt reactor and fabricate, assemble, and test operate the plant at McMurdo Sound. The reactor will be of the pressurized-water type, moderated and cooled with light water. It will be assembled at the factory in packages and shipped to the site for erection.

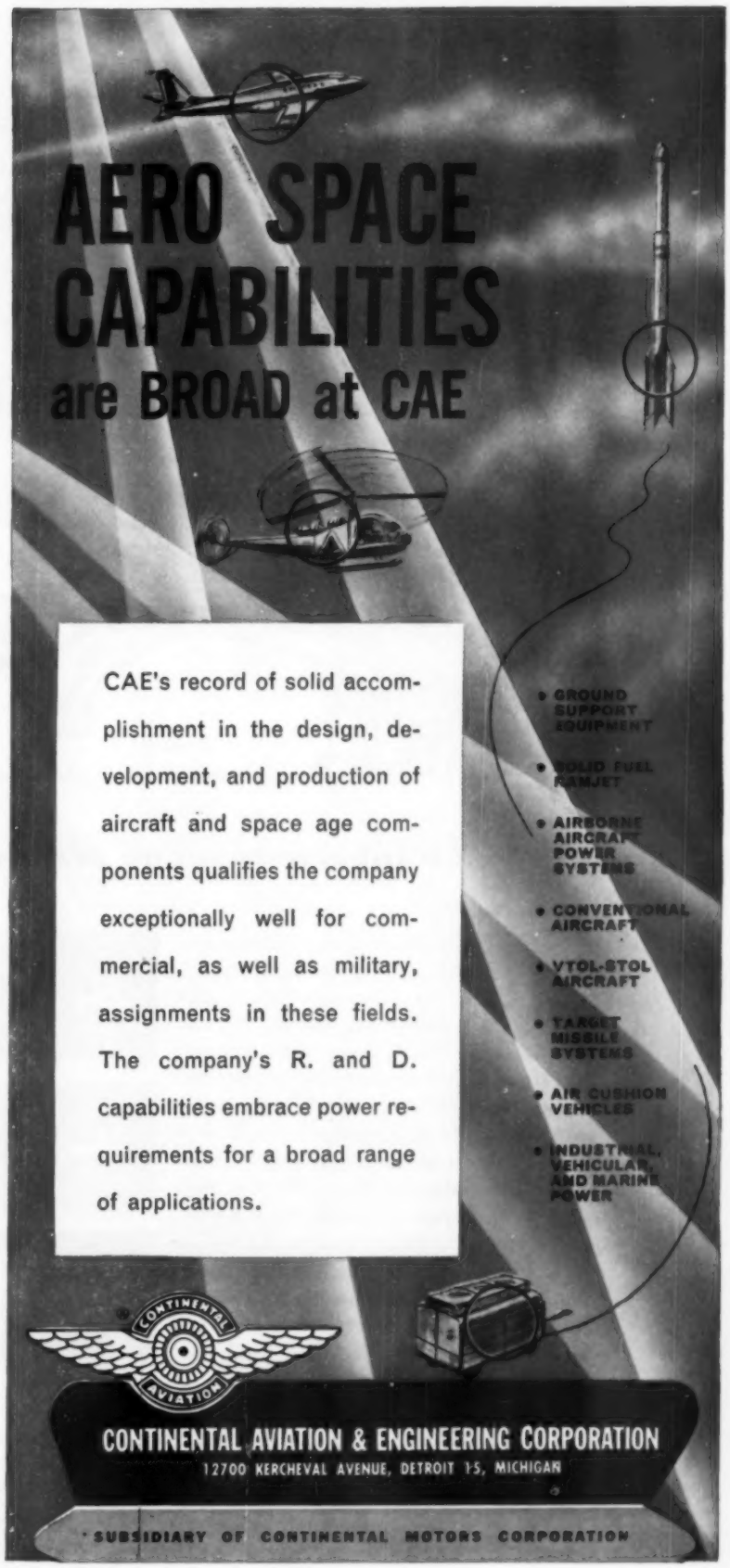
In accepting the proposal as a basis for negotiations, the Commission has taken cognizance of the provisions of the Antarctic Treaty now pending ratification which relate to radioactive waste from reactor plants. The plant will be so designed and operated that radioactive waste will be handled in conformity with the terms of the treaty.

Heavy Water Reactors

Atomic Energy of Canada, Ltd., and the U. S. Atomic Energy Commission have signed a memorandum of understanding providing for an expanded program of cooperation in the development of heavy-water-moderated power reactors.

Both Canada and the United States have under way broad research and development programs on heavy-water-reactor technology. The Canadian program includes construction of a prototype, 20-electrical-megawatt power station (NPD) and a full-scale, 200-electrical-megawatt power station (CANDU), both incorporating heavy-water reactors. A research and development study is being made to determine the feasibility of constructing a prototype, 40-thermal-megawatt, organic-cooled, water-moderated reactor.

Under the United States program are the construction of a prototype 17-electrical-megawatt power station incorporating a heavy-water-moderated reactor, a heavy-water-moderated plutonium recycle test reactor (PRTR), and a heavy-water-components test reactor (HWCTR).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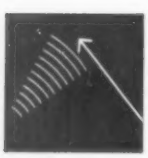
countermeasures problems?



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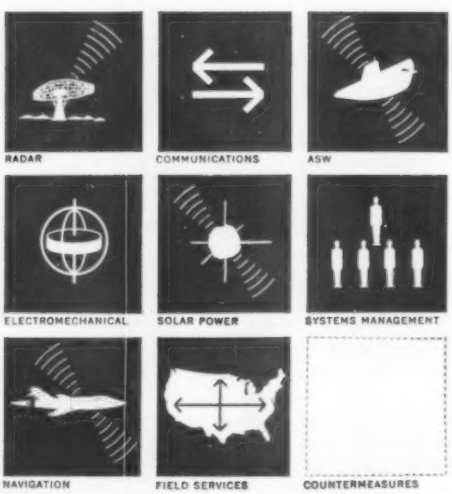

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GEN. GEORGE H. DECKER

Chief of Staff, United States Army

Teamwork for Survival

An important responsibility faces the Army's new Chief of Staff

THE United States today is fighting for survival in a world whose normal complexities are compounded by Communist pressures. These pressures, applied around the globe, affect every aspect of life.

The free nations, dedicated to the dignity of man and the rule of law, are often hard put to maintain their standards while combating the tactics of the amoral, cynical, and ruthless Communist leaders. Great skill is essential for leaders fighting under Marquis of Queensberry rules against fanatics using jungle tactics. Our leaders must possess at least four I's—integrity, intelligence, ingenuity, and inspiration—to contain and defeat the Communist predators whose only deterrent is superior force.

Since only apparent force will contain Communist machinations, tremendous burdens are placed upon the Department of Defense and all the armed services. On a worldwide basis they must meet and overcome the Communist political and psychological intrigues of every conceivable type.

OUR defense establishment has been called the world's biggest business, but this states the case only partially. It is indeed unrivaled in the number of its employees—military and civilian—in the realty which it controls, and in its investment in equipment. Beyond this, however, it is largely the image of the United States abroad. It is the real basis of foreign policy—the insurance factor, the foundation of the treaty obligations of the United States. Its image lends—or lacks—assurances to the smaller countries lying under the very real threat of Communist guns.

In these hours and years of national peril, the task of assuring survival requires nationwide effort. To the familiar defense team of the uniformed services must be added the industrial and scientific resources of the Nation. The fast-growing technology of armament demands the full support of science. The production of new and complex ordnance requires the resources of industry even in periods of relatively restricted budgets.

TO meet these challenges the Army is fortunate in its new Chief of Staff, Gen. George H. Decker. He has experienced warfare in the jungles of the Pacific, held heavy responsibilities in Europe, headed large tactical units both overseas and at home, commanded allied forces in Korea, and served in the Pentagon as the Army Comptroller and as the Vice Chief of Staff.

Furthermore, he has had the opportunity to see the Communist menace in detail at first hand and in over-all review from top executive levels. General Decker can well appreciate the work required of the full Defense Team—Army, Navy, Air Force, Marine Corps, science and industry. With more than enough work for each team member, there is good likelihood of reduced interservice contention for additional responsibilities.

Once a task is assigned, it appears that General Decker will depend upon those responsible to fulfill the mission completely. If failure occurs, the responsible agency can expect strong protest. And the Army can expect him to require it to meet its obligations without qualification.

The Army can expect to receive good management from its new Chief of Staff. This will facilitate the work and accomplishments of the Armed Services-Science-Industry Team.

General George D. Decker, born in Catskill, N. Y., was graduated from Lafayette College with a B.S. degree in economics in 1924, and that year entered the Army as a second lieutenant of Infantry. He was graduated from the Infantry School and from the Command and General Staff School, Fort Leavenworth, Kans.

After service on the War Department General Staff he became Deputy Chief of Staff, Third Army, in mid-1942. General Decker became Chief of Staff, Sixth Army, in May 1944, and held this position until he returned to the United States in January 1946, having served in New Guinea, Leyte, Mindoro, Luzon, and Japan.

After brief tours with the Army Ground Forces and Army Service Forces, General Decker sailed west again in July 1946 to be Deputy Commander and Chief of Staff, U. S. Army Forces, Middle Pacific, Hawaii. Two years later he was commanding the 5th Infantry Division, Fort Jackson, S. C.

In March 1950, he moved to the Office, Comptroller of the Army, Washington, D. C., and became Comptroller two years later. In Europe from early 1955 to mid-1957, he first commanded the VII Corps and later was Deputy Commander in Chief, U. S. European Command.

Moving next to Korea, General Decker assumed the multiple duties of Commander in Chief, United Nations Command; Commander, United States Forces, Korea; and Commanding General, Eighth United States Army.

On August 1, 1959, General Decker became the Vice Chief of Staff, and on October 1, 1960, assumed the duties of Chief of Staff, United States Army, his present assignment.

Our Troops Must Be Ready

Maj. George Fielding Eliot

THE armed power of the United States, as a deterrent to hostile action, is first of all what the enemy thinks it is. The armed power of the United States, as an active instrument of national policy, is first of all what we Americans think it is.

Our Communist opponents, whether of Moscow or Peiping, will not be deterred from pursuing their Communist purposes by American power which they think they can overcome without suffering unacceptable damage—or by American power which they think we will not actually use against them.

We will not, save perhaps in some last desperate extremity, use armed power as an instrument of our policy, or set out upon a course of action which, if challenged, would require us to do so, unless our military power position, in comparison with that of our opponents, enables those responsible for our policy decisions to act with reasonable confidence of success.

The factual basis on which official confidence of readiness to meet a given situation is founded cannot always be set forth fully to the public, either of our own or of allied states. This is not just a matter of security and secrecy; it is also one of complexity, of the interaction of the varying components of power, both friendly and hostile, as viewed from day to day by competent judgment.

Major Eliot is a well-known military analyst for the Mutual Broadcasting Company and naval correspondent with General Features Syndicate, New York, N. Y.

The public mind will judge the degree of official confidence in our military posture by deeds rather than words. Hesitation to act when action seems called for will be deemed evidence of weakness. Obvious readiness to act, reflected by the policies pursued on occasions of crisis, will be accepted as indication of confidence in our power by responsible authorities, and that confidence will be contagious.

Firm policies based on a consciousness of adequate power, pursued over a period of time, will build up a climate of public confidence which will be apparent throughout the world.

Thus our own confidence, shared by our allies and sensed by our foes, must be the cornerstone of our edifice of power in a world where power is still the final guarantee of survival.

The American foot soldier remains the physical and visible as well as the spiritual symbol of that confidence. "We were not sure of you Americans until you sent your sons to stand beside ours on the battlefield," said an allied statesman in World War II. "Perhaps," replied his American listener, "we were not sure of ourselves until we had done that."

IN 1917, we knew we were at war when Congress responded to President Wilson's stirring battle call; but neither we at home, nor our Allies, nor the Germans realized what American fighting power really meant until our infantry was deployed against the enemy in France in the summer of 1918.

Four months later the war was over.

In 1941, the news of Pearl Harbor shocked us out of our cherished dream of giving other people the tools and letting them do the fighting; but the shock effect passed, and in the fall of 1942 the political insight of Franklin D. Roosevelt led him to one of the very rare decisions in which he overrode his military advisers. He insisted on an immediate invasion of North Africa because, as he said, "It is essential that American soldiers should be fighting Germans *somewhere* before this year ends."

Without this visible demonstration, the fundamental strategic decision to concentrate against Germany first and Japan later might well have become unbalanced in wordy controversy.

IN 1950, President Truman's first hope of dealing with the Communist attack on South Korea by using American sea and air power but not American soldiers was quickly snuffed out under the pressure of events. Only by throwing into the struggle every rifleman we could get to the scene—and doing that piecemeal—were we barely able to hold the Pusan perimeter during the critical early weeks of the fighting.

But all this, of course, happened before our own American homeland was threatened with nuclear devastation. What now of the confidence with which, when the chips were down, we faced up to challenge in 1917 and 1941 and 1950? Are we still as confident of our armed power to meet the challenges of today? And if we are, can the soldier still be the symbol of that confidence in an age of space-traveling nuclear missiles?

Let it be admitted that we have been passing through a period of very cloudy thinking —mushroom-cloudy. Appalled by the imagined prospects of nuclear war, we have allowed our fears to take on the coloration of morality. We have talked of the use of force as though this were itself the ultimate evil; but underlying this talk was not so much a feeling of moral conviction as of uncertainty.

This is not a novel reaction. Beneath the noble precepts of the isolationists and pacifists in the interval between the two World Wars lurked the fear of air warfare—the fear of the unknown developed through the imagination—for the first real air-power war did not begin until 1939.

The fears of today are likewise fears of the unknown, for the only two atomic weapons that have ever been used in war were those we exploded at Hiroshima and Nagasaki in 1945. They bear even less significant proportion to the *possibilities* of nuclear war in the 1960's than did the air weapons of 1914-1918 to those of World War II.

From the reaction of such fears upon the minds and imaginations of free men and women, the enemies of freedom distill the psychological poisons by which they seek to paralyze our powers of decision. So Hitler used the fear of air attack in the 1930's, long before he had the actual capability of using air power to deliver an attack or would have dared to attempt it had he been firmly confronted.

So today Khrushchev brandishes his rockets and threatens the free nations with surprise nuclear-missile assault—even though he knows well that the actual delivery of such an assault would trigger the destruction of his own edifice of power and of all the achievements of the Communist revolution.

Hitler's propaganda objective in the 1930's was the same as Khrushchev's now—to build up the power-image of his own state in the imaginations of people everywhere—at home and abroad. Blackmail costs less than war, and, in the nuclear age, is infinitely less risky. For international blackmail, a terrifying power-image is indispensable, as we have learned from the bitter experience of the past quarter-century.

The lesson we do not yet seem to have learned is that for a free people to resist blackmail effectively, a power-image of their own is likewise indispensable—a power-image which gives them confidence in themselves and their associates and breeds a spirit of resolve from which, at need, timely and successful defiance may be born.

In an association of free peoples seeking collective security against a powerful and predatory enemy, the power-image which can win and maintain their confidence must have greater appeal than the appalling simplicity of the power-image evoked by the term "massive retaliation."

It is not enough to be able to say with assurance—as the United States Government is saying today to its allies and its own citizens—that the Soviet Union does not dare launch a nuclear attack upon the free world because of the certainty of devastating retaliation in kind.

While this statement is true, it rests upon a series of technicalities which cannot be conveyed in clear, direct terms to that immense majority of citizens who are unacquainted with the military characteristics of the weapons systems available on both sides of the Iron Curtain. Further, it can be gradually drained of credibility if Communist aggression in limited enterprises is not successfully contained or, if necessary, defeated.

And this is precisely the Communist purpose today—to deprive the Western, and especially the American power-image of credibility, while magnifying its own. The nuclear (deterrent) aspects of our power-image they seek to degrade by their space accomplishments such as the sputniks and moon probes, as well as by well-advertised firings of long-range missiles into specified areas of the mid-Pacific.

THESE accomplishments are known to tribesmen in the heart of Africa and to peasants tapping rubber trees in Indonesia. But what would happen to the Soviet Union if the Kremlin launched a nuclear attack against the United States tomorrow morning could just barely be made convincingly clear to a carefully selected audience of university graduates by a panel of fully informed military and scientific lecturers freed of all security restrictions.

The Soviet power-image has another aspect. The Soviet Army also has been made widely visible. The Soviet soldier is an unwelcome resident in a number of countries in Eastern Europe. His

deeds in Hungary are well remembered. He was visible throughout the world on television screens and the front pages of newspapers in the massive person of Marshal Malinovsky on the occasion of the collapse of the Summit conference.

Moreover, American and other Western spokesmen never seem to weary of paying tribute to the Soviet Army by the constantly repeated admission that the West cannot find any way to match Soviet superiority on the ground except by the use of what are called tactical nuclear weapons. Since the number of men of military age in the NATO countries of Western Europe (without counting the United States) is fully equal to the number of such men in the Soviet Union, this amounts to an admission that the free peoples of Europe are unwilling to make the sacrifices necessary to create a more favorable military posture for their common security.

That this latter achievement is widely accepted as impossible is grim testimony to the success of the Soviets in establishing the credibility of the army aspect of their power-image.

The West—and especially NATO—has indeed been beguiled into a trap in seeking to offset Soviet ground-force superiority in manpower by the device of increased nuclear firepower for NATO forces. This device has not contributed to the credibility or acceptability of the Western power-image, especially among the continental peoples of NATO. A military posture in which the only alternative to Soviet invasion is nuclear war on the home front inspires no confidence in the prospective victims of these alternative catastrophes.

THE target of Communist ambition is the mind of free humanity. Its ultimate weapon in despair. Our target is the same. Our ultimate weapon is hope. For hope to live and burgeon, despair must be conquered. There must be a sense of security for simple people—security for homes, working places, the future.

Of this basic security the soldier is the accepted symbol—the soldier who stands between the threatened village and the Communist raiders, the soldier whose self-reliance and disciplined fighting qualities provide tangible assurance of protection. This is visible security. The confidence the soldier engenders brings with it the courage to participate in defense of home and workshop if need be.

It is therefore a primary purpose of Communists seeking to overturn a free society to break down the confidence of the people in the armed forces or those of their allies. Thus, during the guerrilla war in Greece, the murderous savagery of the Communist raids on villages in what were supposed to be protected areas had as one of their purposes the destruction of popular confidence in the ability of the Greek National Army to protect the Greek people.

When American tactical planning and American weapons had reenforced the natural fighting qualities of the Greek soldier, confidence gradually returned —and the indispensable final ingredient, willingness of the local populace to form home-guard units to protect themselves against infiltration raids, completed the defense posture of the Greek nation and broke the back of the Communist threat.

We now believe, and with good reason, that we are moving into a period of nuclear stability—a period in which both the Soviet Union and the United States will possess nuclear striking forces which the other side can have no hope of being able to destroy or neutralize by surprise attack. This, in the words of Vice Adm. John F. Hayward, U.S.N., "takes the premium out of the surprise nuclear attack business."

It also takes the credibility out of rocket blackmail. But if the mushroom cloud becomes less charged with the lightning of imminent destruction, against its receding shadow the power-image of the soldier grows taller.

"The image of American power in the years just ahead of us seems likely to be the image of the American soldier rather than the image of the American ballistic missile."

In the coming years of nuclear stability, the Communists are not going to abandon their purpose of extending their domination over others simply because they do not dare resort to nuclear war against the United States in an attempt to gain quick and total victory. Nothing seems more certain than that one product of nuclear stability will be a series of Communist experiments in probing the possibilities of local and limited nonnuclear ventures wherever opportunity appears to offer dividends without serious risks.

Such ventures cannot be resisted by nuclear threats. They will have to be resisted locally, in the areas where they are attempted, by soldiers capable of dealing with whatever scale of peril may there present itself. The power-image of America, and of the free world of which we are the principal champion, will gain the confidence of free men and women everywhere—or lose it—in due proportion to our success or failure in dealing with these limited threats.

INDEED, our confidence in our ability to deter the Soviets from launching nuclear attacks will in large part be judged by the firmness of our reaction to nonnuclear Communist gambits.

Thus the image of American power in the years just ahead of us seems likely to be the image of the American soldier rather than the image of the American ballistic missile. It is not suggested that the American soldier can defend the frontiers of the free world alone. Many of those frontiers must be manned primarily by the peoples who live behind them.

Their ability to defend themselves successfully—whether against actual invasion or against internal threats capitalized on by the Communists—may, however, depend largely on continuing American military assistance in the form of weapons, training, and advice. Their ability to maintain resistance successfully in time of actual crisis may likewise depend on the timely arrival of American help in the form of American fighting men.

Far more important, their will to resist may depend on their confidence that American help is going to be forth-

coming—that it will be sufficient in quality and quantity, neither too little nor too late.

What we cannot afford—what the cause of freedom cannot afford—is even one example of being weighed in the balance of such a trial and found wanting. It will make little difference whether the failure proceeds from material causes or from hesitation and political uncertainty. The fact of failure—if it occurs—will be what will count against us.

Nothing at this moment demands higher priority in our military affairs than the building up of the striking power, the strategic and tactical mobility, and the readiness for action of our ground forces—the Army and the Marine Corps, including their respective Reserve components. Nine chances out of ten, the next emergency we have to meet will be one in which ground combat troops will decide the issue. Nine chances out of ten, time will be the essence of decision. Nine chances out of ten, the only part that nuclear weapons will play in the result will be the offstage part of thunder in the wings.

WE can no longer afford to maintain our ground forces on the present principle of having just barely enough to meet our fixed overseas commitments, plus a so-called "strategic reserve" at home, of which the substance is being constantly ground away between the millstones of fixed commitments abroad and an arbitrary overall manpower ceiling.

Under this system, our Strategic Army Corps, of a nominal 4-division strength, now has only a single division (the 101st Airborne) which is actually ready to move out on short notice. The Army this year had to scrape and pinch and rob Peter to pay Paul in order to get together a single additional Infantry battle group needed for the Pacific.

The Marine Corps has had each of its 3 divisions cut back from 9 battalion landing teams to 7 and is now scraping up odds and ends of manpower from every possible source in order to restore 2 of the lost battalions to meet new responsibilities in the Pacific and the Caribbean. All this does not present a respectable image of national fighting power, especially as we have to do our scraping and pinching in full view of the enemy.

"Our own confidence, shared by our allies and sensed by our foes, must be the cornerstone of our edifice of power in a world where power is still the final guarantee of survival."

What is required for the period of trial we face today is a capability for unhesitating reaction, in adequate force and within acceptable time limits, to any threat which may require the intervention of U. S. ground combat troops.

The cost of attaining such a posture of readiness is well within our means. Such a program might be outlined thus:

1. Maintain overseas forces at roughly the present levels, but with additional U. S. personnel to limit dependence on foreign personnel.

2. Establish home forces of the active Army at a level of eight divisions, four to be ready to move out within twenty-four hours.

3. Provide sufficient airlift to move a division on each coast, simultaneously, to overseas destinations, with adequate initial airborne supply and sealift follow-up.

4. Restore the three divisions and three air wings of the Marine Corps to full strength, with needed ship-to-shore and amphibious support requirements.

5. Provide for 8 high-priority National Guard and Army Reserve divisions, as close to M-day-plus-30 readiness as possible, and make the readiness target for the 29 remaining Guard and Reserve divisions M-plus-90. All Marine Corps Reserve units should attain an M-plus-30 status.

6. Provide adequate availability of individual Reservists as mobilization fillers for all Army and Marine Corps units including Ready Reserve components.

7. Initiate a high-priority procurement program to modernize the armament and equipment of all ground-force elements (Army and Marine Corps, active and Reserve) at the earliest possible date.

8. Establish manpower ceilings which will allow a reasonable margin of flexibility in maintaining the indicated force levels.

These measures would notably increase our capability of dealing with limited emergencies on a global basis. The announced initiation of such a program also should provide us with considerable diplomatic leverage in inducing friendly countries to increase their own defense capabilities.

IN our own country, a new sense of purpose and of readiness to fulfill that purpose would spread throughout the land. The influence of such a program would reach into every community where a National Guard or an Army or Marine Reserve unit has its home; into every family which includes a young man with a Ready Reserve obligation. Everywhere there would be a sense of pride and participation.

It is not suggested that the increased ground-force readiness outlined above can fulfill all our military needs any more than an adequate nuclear striking force can perform the task of the soldier. We need both in due measure. We need also the essential sea-control forces of the Navy, to assure both the safe and early delivery of the soldier when and where he may be needed, and the secure deployment and operation of the sea-based elements of our nuclear deterrent. We need air power, sea-based and land-based, of the types and qualities required to support and supply the soldier and bring timely air support to our allies.

We need to be able to deny the use of the world's sea lanes and air lanes to hostile forces, and to use them for our own purposes.

It is not enough that this power should exist in fact. It must exist also in the minds and imaginations of free men and women everywhere. And its identifiable, visible, and understandable image must be, now as heretofore, the familiar image of the soldier.

Nuclear Flight Nears

Artist's conception of possible Air Force nuclear aircraft (Air Force photo).

First U.S. atomic-powered airplane is scheduled to fly in 1965

Vern Haugland

THE aircraft nuclear propulsion, or ANP, program, after years of blowing hot and cold, has come at last upon a firm target date. The first flight of a United States airplane using nuclear power is planned for "about 1965." That, apparently, is about as firm as a schedule can get in an effort of such broad ramifications.

The atomic-powered airplane will not be the enormous craft once popularly envisioned, but will be about the size of today's B-52 jet bomber. It also will use jet engines, but the heat for the turbine power plants will be provided not by the combustion of kerosene but by nuclear reactors.

The Defense Department, after years of indecision, recently chose a relatively simple goal for its first nuclear-powered aircraft. Says Brig. Gen. Irving L. Branch, Chief of the Aircraft Nuclear Propulsion Office: "It will be the easiest and best possible flight system for research and development, the simplest to build and maintain. It will not be the NX2 airplane, the so-called CAMAL—continuously airborne, missile-launching and low-level penetration—system planned as a military weapon. In flight it would be a learning device instead of a military weapons system."

Mr. Haugland is the Washington aviation correspondent for the Associated Press and author of several books including "The AAF against Japan."

The first plane will be slower than many craft now flying; it will not, in fact, even be supersonic. But it will have a unique virtue outweighing many of the best qualities of faster, cheaper, chemically powered aircraft—almost unlimited range and endurance. It will be an early step toward development of a missile-launching plane that can remain continuously aloft for long periods and that can fly at low levels, below radar screens, without the fuel penalty imposed upon conventional aircraft at low altitudes.

Two manufacturers well known in the aircraft-engine industry have contracts to develop the nuclear power plants for flight testing. General Electric Company, at Evendale, Ohio, and at the Atomic Energy Commission's National Reactor Testing Station near Idaho Falls, Idaho, has been making impressive strides with the direct-cycle approach.

SOMEWHAT less advanced on the development scale, because it is a more complex design with perhaps greater potential, is the indirect-cycle engine of Pratt & Whitney Aircraft, Middletown, Conn. The Air Force says both approaches are feasible, and there is as yet no technically acceptable way of choosing one over the other.

Convair Division of General Dynamics Corporation, Fort Worth, Tex., was chosen in March 1959 to work with the Nuclear Propulsion Division of

General Electric in the initial design of a nuclear-powered bomber prototype. The Convair craft has been given the designation of Model 54. Both Convair and the Marietta, Ga., division of Lockheed Aircraft Corporation had worked on preliminary design studies. The Air Force decided to support limited design work at Lockheed, and assigned the Georgia Nuclear Laboratory of Lockheed to continue experiments on radiation effects.

So much for the quick over-all picture. Now for the background. As far back as 1944, men in the Air Force foresaw the possibilities of nuclear power for sustained flight. Six months before the first nuclear explosion near Alamogordo, N. Mex., the Air Force started discussions with Dr. Vannevar Bush, then Director of the Office of Scientific Research and Development, on the possibilities of nuclear-powered aircraft.

Later discussions with Maj. Gen. Leslie R. Groves, head of the Manhattan Project, led to a study contract in May 1946 between the Army Air Forces and the Fairchild Engine & Airplane Corporation, Hagerstown, Md., to determine the feasibility of nuclear energy for the propulsion of aircraft (NEPA).

In 1948 the AEC established at the Massachusetts Institute of Technology a separate study group designated as the Lexington Project, also to determine the feasibility of nuclear propulsion for aircraft. The Lexington group concluded that, if the national interest warranted the expenditure in manpower, material, and money, a strong development program should be undertaken. The study indicated that a program leading to a nuclear-powered aircraft would take fifteen years and cost well over a billion dollars.

ON this basis, the NEPA program at Fairchild was phased out in 1950, and the AEC joined the Air Force in a more dynamic effort known as ANP. Its main objective was to develop within three to five years information on reactor materials, shielding, and powerplant and aircraft design, so that the feasibility of achieving nuclear-powered flight could be evaluated on a firm basis.

In 1951 it was decided that sufficient information had been obtained to warrant the demonstration of nuclear flight. General Electric was given a contract to develop a propulsion plant, and Convair was assigned application studies and a B-36 "flying test bed" program aimed at first flight in 1957.

The program proceeded with this objective until 1953 when the Defense Department decided that it should be reoriented toward the development of parts that would provide higher performance. Early in 1955 the Air Force established an operational need for a nuclear-propelled bomber that would cruise at subsonic speeds on nuclear power alone and would be capable of a high-altitude supersonic dash by augmenting the nuclear thrust with chemical fuel. An effort was made to meet these requirements in a project called Weapon System 125A.

In 1956 progress was reviewed, however, and it was concluded that it would be ill-advised to continue a full weapon-system-development program to meet the high performance requirements until further advances in reactors could be achieved.

Thus, over the years, ANP underwent a series of speed-ups and slowdowns resulting from studies by a variety of boards and committees appointed from Presidential, Congressional, Department of Defense, and Atomic Energy Commission levels. In July 1959, Rep. Melvin Price of Illinois, Chairman of the Research and Development Subcommittee of the Joint Committee on Atomic Energy, conducted the first public hearing on ANP. Observing that during eleven years the Joint Committee had conducted thirty-six hearings, all in closed session for reasons of national security, Mr. Price said:

"Since 1946 . . . the program has been marked by many changes in its general orientation and in funding levels. It also has been marked by a lack of well-defined objectives and by administrative indecision."

In October 1958 the Air Force issued its operational requirement for the CAMAL system which would provide a high-subsonic-speed nuclear-powered aircraft with long flight endurance, large payload capacity, and the ability to launch stand-off missiles and penetrate an enemy heartland at minimum altitude.

The public hearings conducted by Representative Price brought to light a new Defense Department decision to delay an ANP flight program because of inability to meet the CAMAL system requirements. Dr. Herbert F. York, Director of Defense Research and Engineering, told the subcommittee that the state of the reactor-materials art had reached the point where manned nuclear flight could be demonstrated by an aircraft "of very marginal performance."

DR. York said that such a flight program, if started at that time, would have these negative effects:

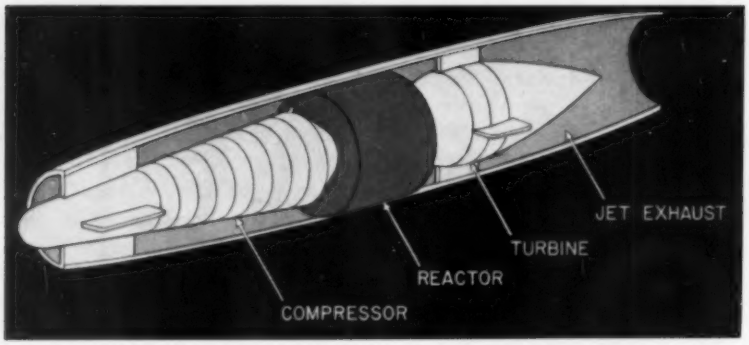
1. It would divert resources, including money, top-rank manpower, and facilities from the more crucial and fundamental problems still awaiting solution; namely, the development of a sufficiently high performance and long-lived power plant.

2. Many of the experimental results and much of the experience obtained from premature flight of a power plant using interim materials, and of a possibly dead-end design, might be erroneous and misleading.

He added that the capability for producing a reactor-engine combination suitable for militarily useful flight had not yet been established but appeared to be "theoretically possible" both for the direct- and the indirect-cycle systems.

Maj. Gen. Donald Keirn, General Branch's predecessor as head of the ANP project, had advised the subcommittee that postponement of the move into a flight-test program would be costly because "year by year the program becomes $150 million more expensive." General Keirn said nuclear flight testing could be accomplished in four or five years at a cost of about a billion dollars, including only $150 million for the airframe program.

"No matter when we start a flight program, be it now or two years from now, the cost will still be another billion dollars."



Cross section of potential direct air cycle nuclear propulsion system resembles conventional jet engine with atomic reactor replacing combustion chamber.

Through June 1960, the ANP program had cost $990,600,000. Air Force projects accounted for $517 million of the total. The Navy, which has had an undeviating requirement since 1950 for a general-purpose patrol, antisubmarine warfare, airborne-early-warning type aircraft of maximum range and endurance —preferably a water-based aircraft— spent about $14.5 million of the total. The AEC accounted for the rest.

Also under way are multimillion-dollar research and development programs in the application of nuclear propulsion to missiles—air-breathing types, ramjets, and rockets. Nuclear propulsion appears attractive also as an auxiliary or secondary power source for satellites and space vehicles, and is of primary interest as a main energy source for transportation through outer space.

BOTH of the two basically different approaches to nuclear propulsion— General Electric's direct air cycle system and Pratt & Whitney's indirect-cycle system—can be used to operate turbojets, turbofans, or turboprop engines. In the direct air cycle system, the air which drives the propulsion machinery is heated by being passed directly through the reactor. In the indirect-cycle system, a liquid coolant is circulated through the reactor and is then passed through an air radiator which heats the air to the temperature needed for propulsion.

Reactor development is, of course, the heart of the ANP effort. The Air Force says that it has solved the shielding problem, but high-temperature materials for reactors are still under research.

When the direct-cycle program was started in 1950, the state of the art in nuclear reactors was expressed by huge, cumbersome arrays of solid-fuel elements, operating at temperatures below 1,000 degrees Fahrenheit, cooled by circulating water, and shielded by massive amounts of concrete. It was calculated, actually, that in order to reduce to a harmless level the radiation field of a 100-megawatt aircraft reactor, a reactor shield assembly of concrete about 21 feet in diameter weighing about a million pounds would be required.

At Evendale and on the desert 50 miles northwest of Idaho Falls, General Electric experimented with its dependable J47 jet engine, well tested in the Air Force B-47 bomber program, modified as an X39 engine using a nuclear heat source. In 1955 G.E.'s heat transfer reactor experiment No. 1, called HTRE-1, began as a test of a ground version of a complete aircraft nuclear power plant.

The assembly for HTRE-1 consisted of a reactor, a radiation shield, two jet engines, ducting, control parts and instrumentation—all called a core test facility because it was designed for insertion of different reactor cores as they were developed. No attempt was made to restrict size or weight to those likely to be needed in a flight model.

On the contrary, the assembly was made large deliberately for ease of access and for the extra equipment to provide detailed test data.

In January 1956, the engines were mated with the reactor, and the experiment was operated successfully. It was a triumphant test of heat transfer, but not of shielding.

The first series of experiments was followed by HTRE-2, which tested ceramic rather than metallic fuel elements —particularly those of beryllium oxide. Like HTRE-1, HTRE-2 produced only enough thrust to run one jet engine.

A new assembly of nuclear power, HTRE-3, progressed to a high-temperature fueled core, in excess of 1,500 degrees temperature operation, cooled by air and moderated and shielded by solid components in a simulated flight position. For the first time the reactor core was run horizontally and in a relatively compact package as it would be in an airplane. For the first time a nuclear reactor produced enough energy to run both jet engines.

Where HTRE-1 had produced up to 20 megawatts of heat, HTRE-3 averaged 33.5 megawatts, and ran for 125 hours, including 65 hours and 10 minutes of continuous operation. At 460 miles an hour, a nuclear airplane on such a sustained flight would have flown some 30,000 miles. By early summer of 1960 the test totals on the three experiments had mounted to 550 megawatts hours for HTRE-1; 110,700 for HTRE-2; and 5,000 for the relatively new HTRE-3.

In mid-1960 the direct-cycle reactor assemblies were transferred, their 32-foot-high structures mounted on coupled freight cars, from the initial engine test facility at the Idaho Falls station where they were developed to a tremendous new flight engine test facility some distance away. The hangar-type FETF, largest building of its kind and roomy enough for the Wright Brothers to have flown circles in, is 90 feet high in the center, 320 feet wide, and 240 feet long from front to back. The program to develop ANP needs plenty of elbow room, and it has it on the Idaho desert reservation 100 miles square and in the huge hangar.

SAYS Col. Tyler A. Redfield, Air Force supervisor of the ANP program of the FETF: "The building is big enough to handle the complete frame of any airplane we can reasonably expect to develop."

Plans initially were to install nuclear-powered jets in a complete airplane inside the building and then to wheel

the craft out and test fly it from a runway planned to a length of 16,000 feet—a runway capable of handling a plane weighing at least 300,000 pounds. The tentative plans called for a flight corridor across sparsely populated country to the Pacific coast, with most of the plane's flight testing to take place over the Pacific ocean.

The Air Force decided that the cost of building the long runway and of other flight facilities construction would be prohibitive. Plans were changed. The nuclear engines would be merely ground-tested with the airframe and instruments in the mammoth building, while actual flight tests would be conducted out of Edwards Air Force Base, Calif.

IT is estimated that a nuclear-powered aircraft will weigh on the order of 500,000 pounds. The first one will be designed for a speed of Mach 0.8 or 0.9 —550 to 600 miles an hour. At 35,000 feet it is probable that the reactor power would be about 300 megawatts.

The Convair Model 54 will have swept wings and a long fuselage, rather like that of the B-70 supersonic bomber but not on the B-70 scale. The crew will sit far forward in the nose, in an instrumented compartment heavily shielded from the propulsion end of the plane. There will be no tail, as such, because the tail would receive a great deal of radiation from the exhaust. Instead there are end plates somewhat resembling a high twin-tail—actually, twin vertical stabilizers widely separated so that they are safely out of the exhaust blast.

The nuclear engines—a power package weighing perhaps 200,000 pounds—will be detachable, so that when the plane lands after a flight they can be unhooked and placed in a cooling chamber.

"The power package unbuckles remotely and simply," says General Branch. "The shielding is far outsize in terms of safety. It provides a radiation dose rate to which a crew member could be safely subjected for 1,000 hours a year over a 10-year period. Actually, the lifetime dose rate would be less than what one gets from a chest or foot X-ray or from a wristwatch. In time, we will be able to back off from this excess and reduce the shielding rate."

The first flights will be for a maximum duration of 5 days, or 120 hours. That's as far as the Air Force will want to drive its crews, initially. Meanwhile, in Idaho, as a follow-on to HTRE-3, extensive testing is under way on advanced fuel elements in a considerably higher temperature environment, and the initial engine test area there has been modified to take the Pratt & Whitney indirect-cycle engines.

What of safety? Convair and the Air Force assure us at the outset that under normal operating conditions the plane will pose no threat. It will fly high enough to prevent radiation from reaching persons on the ground; but if it flies low, the radiation received below will be negligible because of the shielding around the reactor.

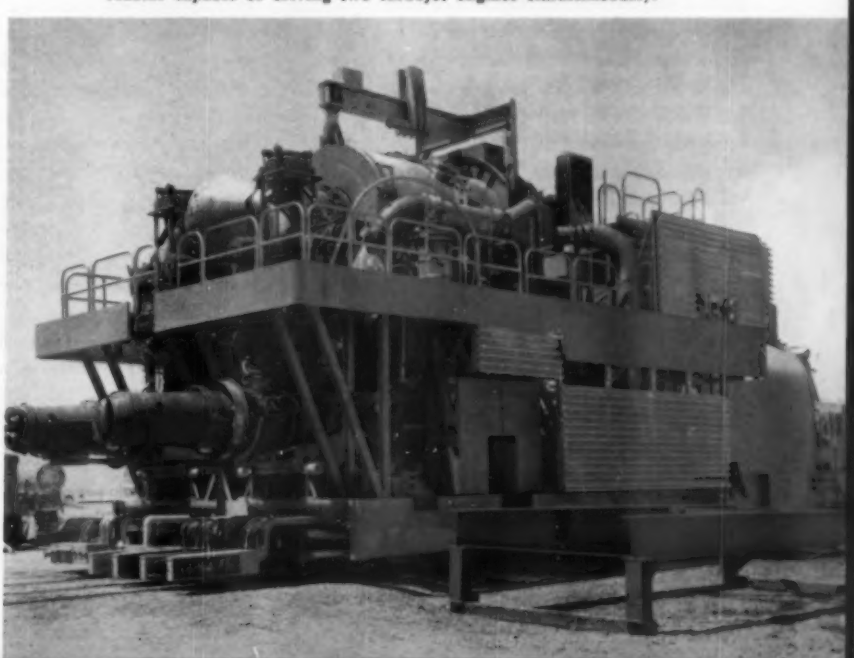
Very little is known about the dispersal, and biological effects of fission products that might be released by a reactor accident, mainly because of the remarkable safety record of the atomic-energy program to date. But if a nuclear-powered aircraft crashes, some fission products very likely will be released. Even with the power plant shut down, the fission products in the reactor core emit enough energy to melt the core if the coolant supply is cut off.

A more serious but much less likely accident could occur if all the reactor safety controls failed in a particular sequence and permitted the reactor power to "run away." This might vaporize the core and release an even greater amount of fission products.

FOR safety reasons, all flight testing will be done west of the Mississippi river, over unpopulated or sparsely populated areas. Special locations about 100 miles apart in the flight corridor and test area will be set aside for emergency landings. The plane will have a conventional jet-propulsion system with more than twice the range necessary to fly to and from the test area. Tests will be conducted during daylight hours only, in bright, sunny weather when forecasts show that there will be no temperature inversion and resultant poor diffusion in the area at the time of landing. Nuclear flight tests will be conducted about two weeks apart to provide complete flexibility as to the weather.

As General Branch puts it: "We have long since proved the feasibility of nuclear propulsion for aircraft; we are now concerned with the highest possible quality in our initial performance. The relatively recent decision to simplify our goal means that we can go ahead and build a fairly simple plane and then learn from it the problems of using atomic power. We are now embarked on a sound technical program, a predictable time schedule to culminate in nuclear flight in the mid-1960's."

Heat Transfer Reactor Experiment No. 3, first direct air cycle reactor capable of driving two turbojet engines simultaneously.



Stop that Missile!

While the Nike Zeus system is a current answer to the threat of a ballistic-missile attack it may have some limitations, and every other possible avenue must be explored for even better solutions

Brig. Gen. A. W. Betts

THE problem of defending the continental United States against the ballistic missile is one of the most perplexingly difficult tasks facing the Department of Defense today. As is common and proper with such matters, many differing opinions have been expressed. The result, as one would expect in a subject of such a controversial nature, has tended more to increase the confusion than to explain the problem to those not directly concerned.

In the case of the ballistic-missile-defense problem, much of the confusion is probably inherent in the problem itself—the greater the unknowns, the greater are the opportunities for varying analyses and conclusions.

As a consequence, some attempt at clarification is in order. The objective here is not substantive resolution of the missile-defense problem itself but rather to present a more precise delineation of the differences of opinion which do exist. An adequate assessment of the situation is difficult to achieve unless the areas of disagreement are clearly and properly understood.

The focal point for discussion of the missile-defense problem is logically the Nike Zeus program, particularly the decision not to release funds for early commitment of production of the Nike Zeus antimissile missile system. The ballistic-missile-defense problem itself is, of course, much broader, as is attested by the $100 million per year worth of exploratory research in the field being undertaken by the Advanced Research Projects Agency. The nub of the issue, as debated in the Executive branch of the Government, the Congress, and the press, appears to be this:

Should the principle of concurrency used so effectively in the ICBM program be applied to the program which seeks a defense against it? In other words, should we begin production before the results of the research and development tests are known?

The most useful approach to a meaningful element of perspective, against which this very young and complicated problem may be viewed, is to review the recent statements of those in authority who have spoken on the matter. Much of their thinking has come to light publicly in testimony before the Congress during hearings on the fiscal year 1961 budget. One finds there the keys to understanding.

The Secretary of Defense, Thomas S. Gates, Jr., responded as follows to a question from Representative George H. Mahon, the Chairman of the House Subcommittee on Appropriations, concerning whether the Secretary did or did not have confidence in our ability to work out a reliable defense against the intercontinental ballistic missile:

"Mr. Chairman, it is loaded with every known kind of difficulty and problem. This is a strange and fast-moving world. I hope some day we will learn more about this problem from the work we are doing in the antimissile field; but what can actually be done, only time will tell.

"The Nike Zeus program was given an enormous amount of consideration by the President's Scientific Advisory Committee, by our Director of Research, by the Joint Chiefs of Staff. It was a very important decision, first from the standpoint of the defense of the United States, and second, financially. The first one is much more important than the financial because an antimissile defense is vital—if it can be successfully developed."

THE Secretary went on in further testimony to indicate that he was not recommending that the Nike Zeus program be pursued for public relations or propaganda purposes but rather that the security of the United States demanded that an antimissile defense be found by whatever means we can devise. He emphasized this point with a reference to the more than $100 million a year which has been made available to the Advanced Research Projects Agency for purely exploratory effort in ballistic-missile defense.

General Betts is Director, Advanced Research Projects Agency, Department of Defense, Washington, D. C.

Somewhat later in the hearings, before the same Subcommittee on Defense Appropriations, Mr. Mahon asked Gen. Thomas D. White, Air Force Chief of Staff, if he believed that the United States will be able to perfect an anti-ICBM. General White answered the question in this fashion:

"I AM afraid it is a long time in the future. I think to perfect such a thing is one of the most important endeavors that we can be engaged in, and we are. I do not mean the Air Force, but the Army has its Nike Zeus and ARPA has under study other systems.

"While I believe that the Nike Zeus is something we must continue our research and development on, I do not think it is ready for production because it does not seem to me that it is going to fill the bill, particularly against sophisticated missiles. It has no discriminatory capability, and while I say that an antimissile defense is one of the most urgent problems we have, I do not think that we have anything in immediate sight."

General Twining, then Chairman of the Joint Chiefs of Staff, said in his testimony before the Senate Preparedness Investigating Subcommittee that, when the problem was referred to the Joint Chiefs of Staff, only one member of the Joint Chiefs was in favor of going ahead with the significant dollar commitments involved in releasing the Nike Zeus to production. Needless to say, there is no question as to which of the Joint Chiefs was the dissenter in this case. Obviously, Gen. Lyman L. Lemnitzer has very strong convictions on this subject. Both he and Secretary Wilber M. Brucker expressed themselves strongly in support of Nike Zeus in remarks before the Defense Appropriations Subcommittee of the House.

Perhaps the Army position was put most clearly in brief by Lieut. Gen. Arthur G. Trudeau, Chief of the Army's Research and Development, in his opening statement before the same Subcommittee:

"I am pleased to report to the committee that since my last appearance before this committee there have been continuing demonstrations of the growth potential of the Nike Zeus system. Design changes, resulting in significant improvements in system performance, have already included increases in power and in sensitivity of radars and improvements in the design and effectiveness of the missile itself.

"On the basis of progress to date, I am confident that the Zeus system will achieve its design objective, that its growth potential is dynamic, and that it can and will be successfully developed to meet and master the ballistic-missile threat of the Soviet Union and extend our knowledge toward meeting the satellite threat in the offing."

It is most interesting, in reviewing the testimony on this subject, to note that in almost every case the reasoning which lay behind the judgments expressed was deleted for security. Most of these hearings were conducted in closed session, and a review for security was made prior to publication.

A Nike Zeus clears its underground launcher in recent successful test of new antimissile missile (Army photo).

Obviously, then, the details of the ballistic-missile-defense problem are obscured by military security. This naturally makes it difficult to discuss intelligently just exactly what is the current status of this problem.

It is possible, nevertheless, to come to some understanding of the situation by looking at the testimony of Dr. Herbert F. York, the Director of Defense Research and Engineering, before various committees of Congress:

"DURING the last two years we have greatly accelerated our effort on the Nike Zeus antimissile missile. While substantial progress is being made in developing this system, the technical problems involved are most difficult. Within a period of minutes, the relatively small incoming warhead and possible accompanying decoys must be detected, tracked, and identified. Within a period of almost literally seconds the actual warhead's final trajectory must be computed and a number of Zeus antimissile missiles fired and guided to the interception point. The speed, reliability, and precision required of this system present unprecedented technical problems.

"The missile itself, while not involving any radical break-throughs in technology, would require very large solid-fuel boosters, and would have to be armed with a rather sizable nuclear warhead. Furthermore, the effective radius that could be defended by a Nike Zeus battery would be relatively small. This would mean that even for a program to defend only a part of the United States, a tremendous investment —up to $15 billion—would be required.

"After the most painstaking review it was decided to press forward as rapidly as practicable with the research, development, test, and evaluation of this system, but not to place it into production. The funds required for fiscal year 1961 will provide the necessary radars, computers, target missiles, defense missiles, test-range facilities, and other equipment required to carry out a full-scale, realistic test program to determine the operational feasibility of the complete Nike Zeus system. It is expected that these tests will provide the basis for a final decision . . .

"In the meantime, we are sharply stepping up our basic research and development effort in the field of active missile defense through Propect Defender. The purposes of this project are: (1) To explore all of the phenomena associated with missile flight which might be useful in solving the defense problem, and (2) To examine the possibilities for applying other techniques to the problems of detection, discrimination, interception, and kill of enemy ballistic missiles. A major objective of Defender will be to find means for making an interception of an ICBM during any phase of its flight."

THESE comments appear in Dr. York's opening statement to the House Defense Appropriations Subcommittee. They were supplemented by further remarks which he made in response to questions put by members of the Committee. Perusal of the Committee's public record suggests again that the most interesting technical details were probably discussed within the limits of the parenthetical phrase, "discussion off the record."

However, Dr. York made some very interesting comments which can and should be noted. He indicated that studies had been made about the use of a terminal defense system to protect either our strategic deterrent capability or our population. He said that it appeared to many people that there were better ways to accomplish these two purposes than to make a $15 billion investment in a terminal defense system like the Nike Zeus.

Dr. York stated that, per invested dollar, fall-out shelters would provide a more effective way of protecting the people. He also indicated that he thought the protection of our deterrent forces in the short term might be better accomplished by means of hardening launch sites, and in the long term by increasing their mobility. He expressed the thought that one also could use an air alert or ground alert with effective warning.

It was his estimate that a $15 billion commitment to the Nike Zeus would protect that area occupied by about 40 per cent of the population, but he did not attempt to assess the level of effectiveness of the system that could be expected over that area.

Within the Office of the Director of Defense Research and Engineering, the problem of air defense generally has been assigned to the Assistant Director for Air Defense, Dr. J. P. Ruina. In a statement before the Committee on Government Operations of the House, he addressed himself in a somewhat more specific way to the subject of an active defense against ballistic missiles.

"The Nike Zeus program is being carried on by the Department of the Army," Dr. Ruina said. "It is being designed as a terminal system, one which will shoot down the missiles close to their impact point. Although the Nike Zeus system must of necessity be far more sophisticated in its electronics than is, for example, BMEWS, there is little doubt that it can be effective against low-rate-of-arrival single warheads.

"This is no mean achievement in itself and should not be underestimated. Ballistic weapons from stones to rifle bullets have never been successfully attacked in this way before, and it is a tribute to the technical competence of the engineers working on this program that well-informed scientists agree that the approach is feasible.

"When the probability is considered, however, that the enemy can, without prohibitive cost to himself, provide for nearly simultaneous arrival of multiple targets, either decoys or perhaps even true warheads, then it is clear that in its present design the Nike Zeus' firepower can be rather easily saturated. The ground electronics of the system are also vulnerable to blast, so that a Nike Zeus battery can be rather easily 'taken out.'

"These are some of the fundamental reasons that a production decision on Nike Zeus has been deferred. A majority of the Joint Chiefs of Staff concurred with this decision."

The statements reviewed thus far were made by people who have had access to whatever they wished to know about the ballistic-missile defense problem. For purposes of comparison, it is enlightening to take a look at how well the problem is understood by the public generally. Perhaps it is unfair to single out one writer, but the following recent news story concerning this subject is noteworthy:

"Zeus must be ready to fire within fifteen minutes at most, after warning is received, and it must hit a target the size of a barrel which is going ten times as fast as a fast bullet.

"As if this were not problem enough, detractors of the program have gone out of their way to discover nebulous handicaps the Zeus must overcome. One of the most preposterous, in the view of many proponents, is the idea that an enemy might fire decoy missiles to throw Zeus' complicated tracking equipment into confusion. All of the decoy proposals ignore a key fact.

"During the critical years after 1963, Russia's attack capability will be limited by the number of vehicles she can launch. Conservatively, she will have the capacity to build 10 nuclear warheads for every complete ICBM. Why, then, should valuable rocket transport be wasted on duds?

"Unless the decoy counterfeits an armed missile exactly there would be no point in firing it. Modern radar can distinguish quickly and easily between objects moving at rapidly different speeds and can determine courses so accurately that anything not headed toward a logical target can be ruled out in seconds."

THIS illustrative quotation brings us close to the heart of the problem of ballistic-missile defense. From a responsible, knowledgeable source there is a rather clear indication that such things as decoys and multiple warheads could in some measure degrade the effectiveness of a terminal-intercept ballistic-missile-defense system.

On the other hand, apparently at least some segment of those interested in this problem believe very firmly that complexities such as decoys are simply impracticable. They would argue that such items should not be considered a part of the problem of assessing the effectiveness of a terminal-intercept system.

It is not possible in an unclassified discussion and with a limited amount

of space to go into the details of what can or cannot be done to evade any given defense system; however, it is possible to say something about the dimensions of the problem which might contribute to a better understanding of it.

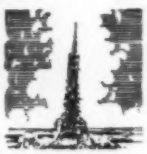
In the first place, one must consider lead time. The number of things which an intelligent enemy can do to evade any defensive system obviously is affected by the length of time it takes to develop, produce, and deploy the defensive system in question. If one goes back to the early 1950's, it would appear that the U. S. set out to develop, produce, and deploy its defensive capability in the form of the Nike Ajax and manned interceptor aircraft on a time scale that was significantly shorter than that required for the enemy to develop and produce aircraft capable of negating the effectiveness of those systems.

The combination of the many air-defense systems available to us over the past six years—Nike Ajax, later replaced by Nike Hercules, and manned aircraft supplemented by air-to-air missiles—certainly at all times has kept us qualitatively ahead of the expected manned aircraft threat. This does not mean we have had or now have a one hundred per cent effective defense against manned aircraft. It does mean that our air defense was and is sufficiently effective to create major uncertainty in the plans of a potential attacker.

THE point to be made is simply this: In committing to production either the Nike Ajax, the Nike Hercules, the Bomarc, or the Falcon missiles with Century interceptors, we were virtually certain that they would be at least abreast and probably ahead of the threat by the time they were produced and deployed on site. In fact, there is probably no manned aircraft flying today which is inherently capable of penetrating with impunity our current continental U. S. air defense system.

It would be incorrect, of course, to leave the impression that those production decisions were easy. The problems of decoys and electronic countermeasures were argued *ad nauseam*, and air-to-surface missiles were added to provide further uncertainty. But our fundamental knowledge of the major factors involved was adequate to resolve those uncertainties—at least sufficiently well to get reasonable agreement among the technical people concerned.

At the heart of the ballistic missile defense problem today is the fact that there is little over-all agreement on the nature of the threat that will face us some four to ten years from now. That the enemy will have ample thrust to carry many multiple warheads and decoys with each missile is generally accepted by knowledgeable technical people. How many and how effective they will be in degrading a sophisticated defense is anything but accepted.



Most informed, technically competent individuals concerned with the ballistic-missile-defense program do not doubt that the Nike Zeus system will be able to intercept and destroy the effectiveness of a single, incoming IRBM or ICBM warhead; moreover, it is quite clear that the technical team concerned with development of the Nike Zeus system is convinced that they know how to solve a large part of the decoy-discrimination problem—just how large a part is still unknown.

This does not, however, change the fact that our knowledge today of the over-all reentry physics and related decoy problem is inadequate. At least it is not adequate enough to get reasonable agreement on who will be ahead in the 1964-1970 time period—the attacker or the defender. Unless we can gain sufficient understanding of the problem to agree on a 1964-1970 threat, it is hard to see how we can ever hope to come to a definitive assessment of the defense effectiveness one can expect in a realistic, all-out attack that might take place some four to ten years from now.

This fundamental uncertainty is only part of the problem. The commitment to any ballistic-missile-defense system means at least one to two billion dollars a year. While this is only a fraction of what air defense is now costing us, it is also merely a supplement to air defense; it cannot replace that air defense for many years, if ever.

This means that, in the contest for funds, those responsible for defense always must contend with those who argue that the best defense is a good offense. Some people forget that for a nonaggressor nation, a strong active defense is the best hope we have of being able to destroy a significant part of enemy attack capability. Active defense is, in effect, a counterforce capability.

Obviously, we must go ahead as rapidly as possible to develop and test the Nike Zeus system. We must at least learn enough about the problem to enable us to evaluate it competently and to learn how to defeat an enemy ballistic-missile-defense system when he gets one.

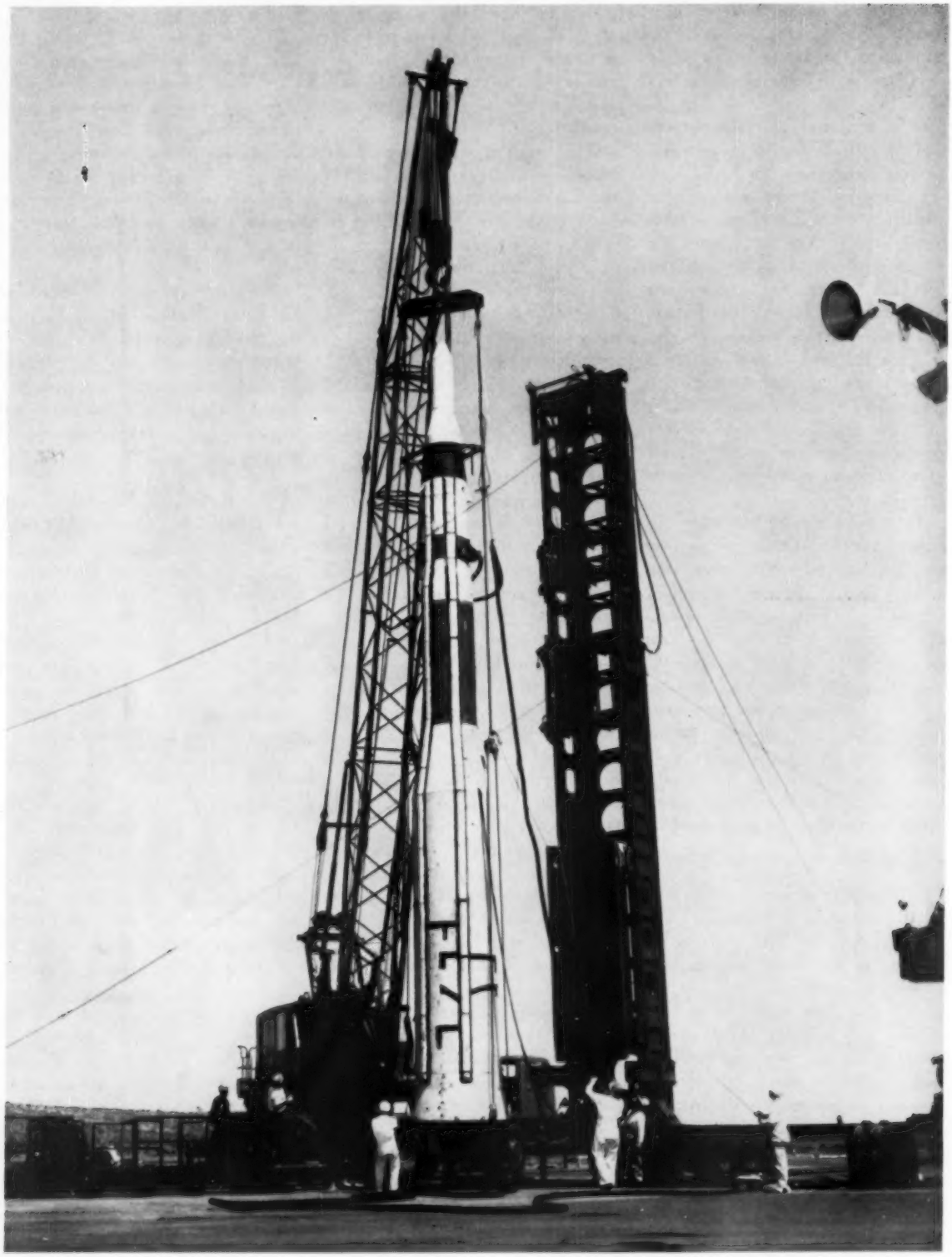
AS to the necessity for a vast amount of exploratory effort in the ballistic-missile-defense area, there is no significant disagreement. In fact, the Advanced Research Projects Agency program for ballistic missile defense, called "Defender," represents the first time that over $100 million per year has been allocated for what might be called broadly state-of-the-art effort in one area of interest. Surely this is a measure of the importance assigned to finding solutions to these many problems.

The ARPA Defender team is working in very close cooperation with the Nike Zeus development program. ARPA is thus the mechanism for bringing to the missile-defense problem the combined efforts of literally dozens of technical teams across the country including in-house efforts of the Army, Navy, and Air Force.

We are making every effort to fill the voids in our technical knowledge in areas such as reentry physics, discrimination, kill mechanisms, and the nature and capability of decoys. This leaves the Nike Zeus development team free to concentrate on the tremendous problems of making that system responsive to design requirements.

There is every confidence that the Nike Zeus system will meet these requirements on the time schedule the development team has set for itself.

Minuteman Makes Ready



The Air Force Minuteman intercontinental ballistic missile is shown above being lowered into an underground launch silo at Edwards Air Force Base, Calif. Designed for ultimate use by the Strategic Air Command, the 3-stage, solid-propellant weapon also can be fired from above-ground launch pads and railroad cars as well as from silos (Air Force photo).

Arsenals Are Essential

The continued operation of small-arms and ammunition arsenals will provide an efficient and workable method of utilizing to the best advantage the capabilities of members of the Industry-Ordnance Team

Maxwell R. Warden

THE wisdom of maintaining Government-owned and -operated arsenals is a matter of primary concern not only to the national defense but to the small-arms and small-arms-ammunition industry in this country. I would like to state the case as I see it on behalf of this industry which I represent in my capacity as chairman of the Small Arms and Small Arms Ammunition Division of the American Ordnance Association.

The seriousness of the times makes desirable a restatement of our views and a reaffirmation by the Department of Defense of a long-established policy of our Government as to the development and procurement policies for small arms and small-arms ammunition. While the established policy is time-honored and goes back to the beginnings of our country as a nation, the successive steps in the development of that policy since World War II are well worthy of recall.

IN the years immediately following World War II, the industry, as represented in this Division of the A.O.A., met at the invitation of the then Under Secretary of War (Kenneth C. Royall, at that time charged with the procurement responsibilities for the Army) with the then Chief of Ordnance (the late Maj. Gen. Everett S. Hughes) to consider a pressing question. It was: whether the Government's peacetime requirements of small-arms ammunition, in mass-production quantities, should be obtained from Government arsenals or from commercial ammunition companies to the exclusion of Government arsenals.

Mr. Warden is president of the Remington Arms Company, Bridgeport, Conn., and chairman of the Executive Board of the A.O.A. Small Arms and Small Arms Ammunition Division. *An earlier discussion of the Arsenal system appeared in the July-August 1960 issue of* ORDNANCE *in the form of a report prepared by the American Ordnance Association and sent to the Secretary of Defense.*

This group first met on December 3, 1946, and again on February 7, 1947, at the Office, Chief of Ordnance, in Washington. Both Ordnance and industry representatives were eager to profit from their development and production experiences of two world wars, and both conceded the need for a closer liaison between the defense establishment and industry in time of peace.

As a result of these conferences, the following conclusions were reached by the industry and submitted (by letters of February 10 and 11, 1947) to the Chief of Ordnance for his consideration:

1. Permanent Government arsenals should participate in the production of peacetime requirements for small-arms military ammunition. (Pilot-line production by the arsenals will achieve this objective.)

2. If peacetime requirements exceed the pilot-line capacities of the arsenals, the remaining requirements should be produced on other pilot lines installed in the commercial plants of those companies comprising the small-arms-ammunition industry of the United States which will be expected to expand to full-scale mass production in the event of a national emergency.

If peacetime requirements exceed the pilot-line capacities of the arsenals and commercial plants, the Government should *negotiate* with the commercial producers of ammunition for the activation of additional production in appropriate plants.

3. Government arsenals should coordinate development and research on military ammunition. The research and development facilities of the industry should augment and complement those of the arsenals. The results of such research and development should be reviewed jointly by the industry and the arsenals before deciding upon firm specifications for mass-production. The flow of information between Government arsenals and the industry as to research and development subjects as well as production techniques should be bilateral and continuous.

IT was the opinion of the industry, based on its experience in World

Wars I and II, that our national security, in terms of the availability of trained personnel with actual production know-how, both military and civilian, and in terms of adequate facilities for the production of small-arms ammunition, with the least possible delay in the event of a national emergency, would be served by this program.

As a corollary, it followed that industry would be best prepared to perform its role in such an emergency if it were able to work closely with the defense establishment in the peacetime development and production of military requirements.

It was recognized that the Government must rely on the commercial manufacturers of ammunition to mass-produce the requirements of the defense establishment for military ammunition in time of war and also when war is imminent.

On April 30, 1947, the industry was gratified to learn that its conclusions were acceptable to the Chief of Ordnance and, to the extent that available funds and existing statutes permitted, would be followed.

DURING the Korean conflict from June 1950 to July 1953, when the industry was called upon to produce enormous quantities of small-arms ammunition for our armed services and those of our allies, these procurement policies for small-arms ammunition were severely tested and proved highly satisfactory. To the best of our knowledge, the combat forces of the United States and its allies were never found wanting for small-arms ammunition in the field because of any failure or inability of the industry to produce quality ammunition and deliver it on time.

Accordingly, in 1957, ten years after these procurement policies had been recommended by the industry, adopted by Army Ordnance, and put to the test in Korea, the industry was pleased to learn from the then Chief of Ordnance (Lieut. Gen. E. L. Cummings) that these recommendations still represented Ordnance policy for the procurement of small-arms ammunition.

Because of the current interest in the development and procurement of new small-arms weapons in late 1957 and early 1958, the Small Arms and Small Arms Ammunition Division of the Ordnance Association forwarded recommendations for the procurement of small arms which were essentially the same as those previously submitted, tested, and confirmed for small-arms ammunition.

In the spring of 1958, the industry was advised by the present Chief of Ordnance of the Army, Lieut. Gen. J. H. Hinrichs, that the policies recommended by the industry for the procurement of both small arms and small-arms ammunition had been carefully reviewed by him and his staff and were acceptable to the Ordnance Corps in every way.

We, who comprise the small-arms and ammunition industry today, believe these principles are still sound, and we believe that a program which follows these principles will result in the evolution and adoption of the best available arms and ammunition designs, the best methods of manufacturing, and the training and maintenance of the largest possible nucleus of skilled personnel within a strong arms and ammunition industry.

On the other hand, we believe that a program which departs from these principles will not result in the best arms and ammunition designs nor the best methods of manufacturing. We believe further that the nucleus of skilled personnel in the arms and ammunition industry (and those in Government arsenals) will be dissipated and that the arms and ammunition industry will slowly but surely become disabled to the point where it will not be able to perform its vital role in maintaining the mobilization base.

Specifically, the small-arms and ammunition industry is disturbed about the continued operation of small-arms and ammunition arsenals.

"The Government must rely on the commercial manufacturers of ammunition to mass produce the requirements of the defense establishment for military ammunition in time of war and also when war is imminent."

We recently learned about a bulletin issued last fall by the Bureau of the Budget to the heads of executive departments and establishments (Bulletin No. 60-2, September 21, 1959) the purpose of which was to clarify existing policy regarding competition between the Government and private enterprise.

This policy, we are told, is that the Federal Government will not engage in any commercial-industrial activity to provide a service or a product for its own use if the service or product can be procured from private enterprise through ordinary business channels. Exceptions to this general policy, we are advised, may be justified on the basis of national security, higher costs, or the impracticability of obtaining the product or service from private enterprise.

ALTHOUGH the small-arms and small-arms-ammunition industry in the United States is in sympathy with the objectives of this policy and favors its implementation wherever possible, it is concerned that the continued operation of Government arsenals, which are engaged in the research and development and, in some cases, pilot-line production of small arms and ammunition, may be threatened. It would regard such an interpretation as an undue extension of the policy that the Government should not compete with business. It is of importance to note that the industry's recommendation to Army Ordnance was made many years ago before the present controversy arose.

It is believed that the policies which the industry has recommended and which the Chief of Ordnance of the Army has accepted for the development and procurement of small arms and ammunition will keep the Government out of competition with private business so far as production contracts are concerned.

In the area of research, development, and engineering work there is no real "competition." Military requirements and, hence, military test procedures and design criteria, are usually quite different from their commercial counterparts. It is, therefore, desirable and proper that this type of work should be the assigned mission of a Government arsenal.

The West German Army

With a new organization backed by a long tradition of military competence, this modern defense force, potentially the world's third strongest, is relying heavily on mobility and firepower

Jac Weller

THE West German army is potentially the third strongest in the world. The economy and the industry of the nation, as well as the military experience and traditions of her 50 million stalwart people, make this eventual ranking almost certain. The progress made in a little more than three years is astonishing.

Military progress in Germany isn't a matter of numbers; it is relying heavily on new organization and new ordnance. There was no complete army in being in 1957, but no antiquated military institutions, organizations based on earlier wars, and weapons about to become obsolete either—everything could be of the most efficient modern type.

There was, however, the priceless advantage of combat experience. The high-ranking name officers of the old Wehrmacht were either dead, too old for active service, or tainted with Nazi guilt. But the new Bundeswehr has many veterans from senior NCO's to corps commanders who learned their profession in battle from the central Sahara to Arctic Norway and from the Crimea to Normandy.

NEITHER the Kaiser's nor Hitler's army had a single centralized ordnance department. The Bundeswehr does. The new department tackled the weapons problem in 1957 with courage and imagination. The short-range objective was to get something that would shoot into the hands of troops. However, in achieving this goal, they didn't permanently handicap themselves. Their infantry battalions today have new arms.

Mr. Weller is a recognized authority on small arms as well as an expert on colonial and Civil War ordnance.

Even though phenomenal progress has been made since 1957, it would be inaccurate to say that the entire infantry is presently provided with its full quota of new ordnance. Some supporting weapons and vehicles are presently in short supply; however the units which don't have them are equipped with temporary substitutes, usually U. S. Military Assistance matériel. All the German divisions now have a real fighting potential. Each month that passes increases this potential.

In order to understand battalion infantry weapons and tactics, it's well to know what the German high command is thinking. All Germans now realize the folly of trying to win anything by war, particularly atomic war. Their suffering from World War II conventional bombing was terrible. In another war West Germany would be destroyed at home by thermonuclear weapons, even though the army might be victorious in the field. They definitely don't want war if it can possibly be avoided.

The Germans realize, however, that Communist domination of their country would be worse than atomic war. Many who survived the bestiality of the Russians would prefer death to another Communist subjugation. The West Germans of all parties and in all walks of life are now convinced that their salvation lies in NATO preparedness.

The German Army is trying to make itself just as strong as it possibly can so that it won't have to fight. But if it does, it will hit with great power and speed. They have calmly and carefully evaluated their World War II experience. They will take advantage of German potentialities, but avoid Hitler's errors.

The high command wants the very ultimate in flexibility, movement, communications, and strategic thinking. The concepts of war that won in Poland, in Norway, in the Battle of France, and the early stages of the Russian war are still good. Never in history was so powerful an army as the Anglo-French defeated with such small casualties. Only the great Khans advanced so far and so fast as the Germans did on the Eastern front. All oppose exchanging casualties as in World War I and in the later stages of World War II. Germany cannot swap manpower with the Communists, but can beat them in other ways. To the West Germans, the Red Army is not composed of supermen.

Early in World War II, the Germans used matériel as a substitute for men.

The Spanish Cetme rifle, with greater accuracy in full-automatic fire, is now replacing the Belgian FN in the West German Army.

They sometimes didn't have more matériel than their opponents, but they employed it better. This was particularly true in the Battle of France; the Germans won with their tank concentrations, even though the Allies had a larger total number.

The organization and equipment of German infantry battalions is such as to aid the over-all objective. Weapons power is present to an astonishing degree right in the battalion, but it's flexible and mobile. Even the most modern weapons are only as good as the men handling them and the leaders directing their use. The idea is to multiply battle power by proper concentrations, better teamwork, and more complete training. This principle is understood at every level from corporal to battalion commander.

THE German Army today doesn't really have infantry in the old sense. Foot soldiers alone compose no units larger than companies, and even these are either motorized or mechanized. Larger units are blends of infantry, self-propelled artillery, and tanks. Personnel carriers, according to the new German concept, must not only be armored and have full-tracked mobility, but have a combat capability also. By this they mean that an infantry squad must be able to fight without leaving the vehicle.

A German division now consists of several battle groups. Each of these contains a battalion of tanks, artillery, and three battalions of infantry. There are, of course, supporting units as well.

Let's look closely at their infantry battalion. It's new both in conception and in ordnance. The elements are a headquarters group, three rifle companies, and one support weapons company. Within the near future, not only will every man in this entire outfit ride when called upon to travel but actually will be able to fight while still aboard a vehicle.

The battalion headquarters is split into two units, either one of which can take over complete command of the entire battalion. One is located forward and the other to the rear. The destruction of one would not greatly effect the fighting potential of the battalion.

Each of the three rifle companies has 137 officers and men. A company is divided into a headquarters section of 17, and three rifle platoons of 40 each. A rifle platoon has a headquarters of 8 men and 4 rifle squads of 8 men each.

The battalion support weapons company consists of 5 platoons. One has six 81-mm. mortars and another four 120-mm. mortars. A third has six 20-mm. automatic cannon, and a fourth five 90-mm. antitank guns. Both the last two types of weapons are self-propelled, full-tracked, and armored. The 20-mm. guns are mounted in 360-degree turrets. The fifth platoon has 6 jeep-mounted launchers and 48 guided missiles.

In 1957 small arms were obtained from the U. S., Britain, France, Spain, Belgium, Italy, and Switzerland. But they were considered as temporary only. Standardization on a new family of infantry arms was to be reached as soon as possible.

The first weapon chosen by the new ordnance department was the machine-gun. They preferred their own MG-42 to any other in the world and altered it to fire the 7.62 NATO round. They slightly redesigned the barrel so that it can be changed even more easily. The bolt can now be changed quickly also. The cyclic rate can now be reduced, although the Germans see little reason to do this.

I fired the bipod-mounted MG-42-59 and found it to function perfectly. However, its accuracy on targets in full-automatic bursts is poor because of the 1,300-rounds-per-minute cyclic rate. The group size for a given number of rounds is three times that normally made with the British Bren or the American BAR. The only way you can fire a single round is to pull the next one out of the belt.

THE Germans are, of course, completely acquainted with this feature of their weapon. Their ordnance department personnel have tested dozens of foreign automatic arms of all types, but they still like their own. MG's are seldom fired at visible targets. For area work, they want to deliver as many bullets as possible in a given time. Besides, the high cyclic rate of the German MG's has a desirable psychological effect, even if it doesn't hit anyone.

The next choice was made in relation to the infantry rifle. The Germans felt that the U. S. M1 was definitely superior to its contemporaries. They didn't like its weight, however, or the fact that it would not fire full-automatic. Besides, it was chambered for the .30-'06 cartridge. The FN was immediately available and chambered for the 7.62 NATO round; many were ordered.

The West Germans didn't consider the FN and the NATO round ideal in two respects. First, the ammunition was too powerful for their idea of a personal weapon for general issue. Sec-

ondly, it was not so effective in full-automatic fire as they would like.

The ammunition complaint is an old story. The Germans were planning at the end of World War II to substitute the MP-44 firing the 7.92-mm. short cartridge (a 120-grain bullet at 2,250 feet per second) for both rifles and submachine guns. This weapon certainly had desirable features. It was sufficiently low in power to be fired accurately in full-automatic submachine-gun-type bursts. It was still effective and accurate against men out to a full 300 yards. The Germans, however, did not want to create a NATO rifle ammunition rift. They accepted the 7.62 NATO round for rifles also, but did keep the 9-mm. Luger cartridge for submachine-gun and pistol use.

AFTER extensive tests, the Spanish Cetme rifle was found to be a little more accurate in full-automatic fire than the FN. It had some other minor advantages from the German point of view and is more easily and cheaply produced in West Germany. It's a bit heavier than the FN and has the barrel farther below the line of sight. Both these factors aid its full-automatic fire. The Cetme has now replaced the FN, but both will be in service for several years to come.

I fired both the German model FN and Cetme rifles. Semiautomatically, both give fine accuracy and reliability. In full-automatic bursts, however, neither is entirely satisfactory. Even with the Cetme in a prone position using the bipod and holding the small of the stock down with my left hand, I couldn't get good results. The cyclic rate, 650 rounds a minute, is far lower than the MG-42-59, but the rifle itself just isn't heavy enough to deliver accurate full-automatic fire. It can't compare to the Bren and the BAR.

The German ordnance department finally chose the Israeli-designed "Uzi" from the many modern submachine guns available. It's made under license by the FN factory and is a simple, reliable, and compact weapon that is pleasing to handle and easy to produce. It has a selector switch for semiautomatic and full-automatic fire. The compactness of the arm probably led to its final selection. Its accuracy in full-automatic fire is not so good as the British Sterling nor the old German Schmeissers. This could be improved by cutting down the cyclic rate; however, the Germans like it the way it is. The accuracy, even full-automatic, is sufficient for short-range use, which is all the Germans require from submachine guns.

Pistols have occupied an unusual place in the German Army. In World War II, they issued hundreds of thousands to all ranks for personal defense. These were more important psychologically than practically. Only a little training was done with pistols; practice ammunition was seldom issued. The number of pistols has been drastically reduced, even since 1957. To some extent, the "Uzi" is intended as a substitute for them.

The Germans realize, however, that some men, because of their duties as drivers and team-served-weapon gunners, just can't conveniently carry anything but a pistol. They have chosen their old World War II German P-38 which will fire the first shot double-action. They slightly redesigned this weapon so as to eliminate the possibility of firing it with the slide lock left out and are presently manufacturing these arms in quantity. It takes, of course, the 9-mm. Luger cartridge and is strong enough to fire submachine-gun ammunition.

The Germans are presently using the 81-mm. mortar common throughout NATO armies. These weapons are effective and simple. They also employ the 120-mm. Brandt mortars made in France. These can be towed behind a vehicle all in one piece like artillery. The Brandt is to be replaced by the Finnish-designed Montella, one model of which can be mounted in an armored vehicle.

THE new German 20-mm. automatic cannon is a Spanish design; these weapons are being produced so far only by the Hispano Suiza Company. Solid hard-core projectiles are fired at a muzzle velocity of 1,050 meters a second. This gun will penetrate the armor of most tanks at close range and would quickly put out of action a column of APC's. The cyclic rate is 800 rounds a minute, and the weapon is accurate. It can be fired with explosive projectiles, although such a shell is probably too small to be very effective.

The 90-mm. self-propelled guns are primarily for antitank use, but can be employed for other missions. They are true combat vehicles protected by armor. They normally will fire from a stationary position but do not need any emplacement. The supply of these in the German Army is presently limited. Infantry battalions have U. S. M41 and M47 tanks in their stead on a temporary basis only. The German-designed gun and vehicle are both lighter and

The extremely compact, hard-hitting, and efficient German antitank rocket is normally carried on each army vehicle, ready for field use as required.

more mobile without sacrificing power.

The guided-missile platoon of the battalion support company is at present equipped with an improved version of the U. S. Cobra missile.

The supporting arms are intended to be used in ways obvious from a description of them. The personal-defense arms, submachine guns and pistols, are not considered primary infantry arms, even though there are eleven and fifteen, respectively, in each German rifle company. Between these two types lie the infantry rifles, the machine guns, and the rocket launchers.

THERE is more flexibility here than in most armies. Every vehicle normally carries one of the first-rate, compact German bazookas. It will be removed for use in the field when required by the men carried in the vehicle.

The proportion of machine gun to rifle is somewhat variable. An 8-man squad normally has seven FN or Cetme rifles, all capable of full-automatic fire, and one bipod-equipped MG-42-59. Under special conditions, however, a heavier tripod mount would be supplied. Extra machine guns were issued in World War II, and presumably would be again for primarily defensive fighting. On the other hand, a small-scale infantry attack may be made with rifle-armed platoons only.

I discussed at length with a group of German officers, instructors at their Infantry School at Hammelburg, a theoretical infantry attack in which armor did not take part. We were supposing that a battalion was operating by itself. The first step was reconnaissance to locate the enemy and determine his strength. A security line was established and observation posts set up. The Germans emphasized dispersion, particularly of the fighting vehicles.

Intelligence received about the enemy was assumed to be satisfactory. The hypothetical terrain, shown on a map similar to ours, allowed the proper establishing of a forward and rear battalion headquarters and protected positions for the support weapons. The observation posts already selected were tied into a communications network with both headquarters and the supporting arms.

The mortars were kept together so that a concentrated fire from them would be possible. The guided-missile launchers were well back, but the missiles were to be directed from the O.P.'s. The 20-mm. and 90-mm. guns were pushed as far forward as the terrain permitted preparatory to coming out in the open and giving actual close-up support.

The attack was begun with an intensive mortar barrage; this was assumed to have taken place from 15 to 30 minutes after contact. Two rifle companies then attacked abreast. Each company put in two rifle platoons and supported them with the third. The self-propelled guns added their fire on a visual basis. The third rifle company was held back still in its vehicles to exploit a break-through or cover a retreat.

The four platoons which closed first with the enemy would probably be armed with rifles only. The other two platoons, however, would temporarily have the extra MG-42-59's and gunners. German rifle tactics call for initial semiautomatic fire from perhaps 400 yards down to 200 yards. At this point, a shift to full automatic fire should be made. However, the final assault is done with semiautomatic fire only. The thinking in this connection is that when ranges are long, full-automatic fire wastes ammunition. When the range becomes really short, and the infantry moves forward as fast as possible, full-automatic fire would leave the soldier with an empty rifle when he needs it most. The bayonet isn't considered effective.

The German officers were thinking clearly and logically in this discussion of an unsupported infantry attack, but they didn't seem enthusiastic. As soon as we talked about defensive infantry tactics, however, they were on more familiar ground. They plan to use armor for most offensive operations, but will defend with infantry alone. The battalion support weapons company is partly defensively conceived.

The German officers now explained, with the aid of a second topographical map, a typical defensive situation. Strong points for crew-served weapons were fitted into the terrain. The machine guns, located for the most part well behind the security line, were all coordinated; there were interlocking fields of fire. The mortars and missiles launchers were located well to the rear but could be controlled from multiple observation posts. The 20-mm. and 90-mm. cannon must be concealed for defensive use, so terrain is important. It sometimes will be necessary to emplace these, but the Germans would much prefer to have them retain their mobility.

The pattern of defensive thought seems to be to knock out armor with support weapons and bury attacking infantry with mortar fire and a hail of bullets, mostly from machine guns. The high machine gun cyclic rate and the full-automatic Cetme and FN rifles at ranges below 400 meters give the Germans enormous firepower.

Perhaps the most impressive thing about the West German Army is its lack of complacency. They are proud of their progress but are quick to point out areas where things are not entirely satisfactory. They are willing to work hard in training, discussions, and weapons development.

THE infantry battalion is new; it may be changed slightly from time to time, especially when all battalions are fully mechanized. But they can fight right now, either conventionally or in atomic war. They fervently hope it won't be necessary, but they will do it well.

The Germans "invented" the modern armor and infantry thrust—"blitzkrieg" is, of course, German. The new infantry battalion can move right along with tanks, fully protected by light armor, and it can even fight mounted. But the greater potential of these superb units seems to be defensive, preferably for short periods which precede further thrusts in their area or elsewhere.

The boys handling the weapons will be young and vigorous, but the senior NCO's and field officers will cunningly contrive and stubbornly fight according to plans found effective even when Germany was fighting almost alone against the world. They were tough enemies, but they are now fine allies.

Atomic Age Warfare

The armament of an invulnerable retaliatory force might well contain nuclear-powered aircraft to supplement missile-firing submarines, but the costs of providing such strength must not result in economic ruin

Hoffman Nickerson

IT has often seemed to me that an opinion of a major work is enhanced when the point of view is expressed after the passage of some little time. This is especially true of analyses of our national defense, particularly in these days of fast-moving developments.

In this mood I submit—at the editor's urging—some thoughts I wrote nearly a year ago about Oskar Morgenstern's "The Question of National Defense" (New York: Random House). They are not only still timely, but in my opinion they are probably more timely than ever. The problems daily grow more serious and the proposed solutions more demanding of sober thought.

In these days of atomic and hydrogen bombs, according to Mr. Morgenstern, it would be well for all parties concerned—the U. S., the Soviet Union, and the rest of mankind—if both we and the Soviets had "invulnerable retaliatory forces." Such forces seem by far the most practicable and effective means by which the threat of an irrational war of widespread and undiscriminating destruction would be so much lessened that it might be to all intents and purposes removed.

THE author's second idea is excellent in itself; namely, that we would be far better served than at present if our retaliatory force were composed chiefly of Polaris-firing submarines and of nuclear-powered seaplanes. It could then be made practically invulnerable. The combined military and political advantages, especially in regard to our relations with our allies, are so obvious and so great that the proposal is emphatically worth a good, hard try.

Mr. Nickerson is a well-known military historian and a frequent contributor to ORDNANCE. *He is also the author of several books including, "Can We Limit War?"*

The third part of the book is a harsh criticism of the way in which we are apportioning the vast sum of perhaps forty billions which we are now spending on military preparedness and an exhortation to spend much more. The criticism is well justified, but the exhortation overlooks pertinent and fundamental factors.

At first glance, how can it possibly be an advantage for both of the two chief world powers to have invulnerable retaliatory forces? The statement certainly sounds cockeyed. Surely it must be advantageous for one side in a quarrel to know that its weapons are invulnerable while its potential opponents' weapons are vulnerable!

Sometimes, however, a superficially silly proposition may be a paradox which turns out to be true. And this particular paradox, like many of those in the writings of G. K. Chesterton, happens to be true.

The reasons why it is true can be summed up in the one word—"fear." As yet only Hiroshima and Nagasaki have actually suffered from the new bombs, but from Liverpool and London to Tokyo millions have suffered enough from what are quaintly called "conventional" bombs to make them acutely unwilling to be made targets for atomic and hydrogen explosives.

WE need not go as far as the authors of "On the Beach" and other sob sisters who talk about a possible destruction of all life on the planet. Among scientists even Dr. Linus Pauling does not believe in such a thing. Nevertheless anyone can see that a competition in mutual and vast devastation is physically possible and therefore to be feared. Such a war would be "not only a crime but a blunder."

The essence of the above sentence is the word "mutual." The only way to make the idea of an unlimited atomic war attractive to any government or military planner would be the belief that a sudden surprise attack stood a good chance of wiping out most of the other side's power to retaliate in kind.

This is where the invulnerability of the retaliatory force comes in. As long as either side believes that the other side might hope to prevent effective retaliation, both sides will be afraid that the attempt might be made.

In that case what is often called "tension"—"fear" would be a better word—will be so strong on both sides that, in spite of all precautions, either one might conceivably begin bombing in the mistaken belief that the other side was attacking him. The public was recently told that the crews of a considerable part of the bombing planes of the U. S. Strategic Air Force had been put on a "15-minute alert."

On the other hand if both sides have reason to believe that no sudden surprise attack can destroy their power to retaliate effectively, then both will sleep easier because the chances are that no attack of that particular kind will be tried. There would be a "relaxation of tension"; in other words neither side would acutely fear the other to the same extent.

EVEN though the Soviets may go on hoping that they will some day "bury us," the chances of their trying to go about it with missiles carrying atomic and hydrogen bombs would be vastly reduced. Correspondingly, they would see that the chances, if any, of the United States and its allies being tempted to start a "preventive war" would be lessened in the same way. The matter is as simple as that.

Of course this would not mean that strenuous competition between the U. S. and the U.S.S.R. would cease. That competition might rise to the level of limited war. Nevertheless it would be extremely difficult to make anyone believe in the possibility of an unlimited atomic and hydrogen war.

Throughout history every lasting limitation of war—within the Roman Empire, within medieval Christendom, or in 18th-century Europe—has been supported by appropriate military institutions and weapons. Since the present problem is that of reducing the chances of a war of unlimited bombing, it is natural to ask what should be the armament of an invulnerable retaliatory force?

Obviously, bombing planes which require long runways and missiles which require large fixed launching places are not ideal weapons for such a force, while the advantages of mobile and easily concealed bases are equally clear. It is said, whether truly or not, that the Soviets can launch missiles from railroad flatcars. While our Minuteman is not yet operational, we do have the Polaris missile which can be fired from submerged submarines which have very great cruising ranges and the ability to remain absent from fixed bases for long periods.

The Polaris missiles have a range of about twelve hundred miles which is expected later to become fifteen hundred. As yet, however, we have only a few missile-firing nuclear-propelled submarines.

Moreover, there will be the permanent difficulty of extremely accurate navigation so that the exact point from which the missiles are to be fired will be known precisely. Nevertheless Professor Morgenstern's advocacy of a strenuous effort to provide more such ships is certainly well taken.

He also proposes to supplement our nuclear-powered Polaris-firing submarines with a fleet of nuclear-powered seaplanes, and here the first beginnings of doubt as to his proposals begin.

Certainly such planes would have many advantages. With their vast cruising range and their ability to land on and take off from any moderate-sized body of water, including lakes and rivers, they could approach the Communist land mass from a number of unexpected directions and could range much farther inland than Polaris missiles launched from submarines. Once landed and moored to shore, the planes could be camouflaged.

Finally they would share with the submarines the considerable political advantage of smoothing our relations with our allies, several of whom have refused to allow U. S. military airfields and missile-launching sites on their own territory because those sites might draw fire on themselves in case of war. This would not be the case with submarines and seaplanes which could be in one place today and gone tomorrow. On the other hand, one wonders whether nuclear-powered seaplanes could be militarily efficient.

In approaching the question of military costs, Professor Morgenstern is in full agreement with distinguished men like General Gavin and George Fielding Eliot who insist that the present power of the Bureau of the Budget arbitrarily to strike out this or that item in a complex military program agreed upon by the Joint Chiefs of Staff is seriously harmful. This has absolutely nothing to do with the question of what should be the over-all total to be spent on preparing for war. That is a matter for the civilian branches of government and for them alone to decide. It is purely a question of how the civilian control should be exercised in these matters.

After listening to their military advisers, the responsible civilians—the Congress, the President in his capacity as a civilian official, and the Executive Departments including the Defense Department—have a perfect right to say: "Thus far and no further." But after the global sum has been fixed, then the apportionment of the various items within that sum should be almost exclusively a military matter.

AFTER giving his readers so much reason to praise him, Professor Morgenstern wanders off at last in company with the happy spenders for whom the sky is the limit.

It seems not to have occurred to him that in preparing for war there is no such thing as absolute security, that hardly any military commanders of the past—except perhaps those who also were heads of their governments—have ever thought that they had "enough," and that at the moment an important part of the cold war against Communism in which the United States is at present engaged is an economic rather than a military conflict.

We talk about preserving our liberties, but in fact we are losing much of one important liberty—the freedom to do as we like with our own money. Some thoughtful men are already saying that we are taxing ourselves into socialism.

If that be true, then since economic liberty has helped mightily to make our country great, the sky is not the limit on taxation. If we cannot have reasonable military security for about $40 billion a year, then something is indeed rotten in the U.S.A.

Fleet against Fort

A Southern victory in the Battle of Drewry's Bluff in 1862 saved Richmond from capture by the North and emphasized the influence of sea power on military strategy during the whole course of the war

Rear Adm. John D. Hayes

THE naval superiority of the North in the Civil War reached for thousands of miles along the Atlantic and Gulf coasts and up into thousands of more miles of the Mississippi River system. At the same time much of it had to be concentrated in the waters of Chesapeake Bay because of a man named Robert E. Lee. Lee, in his Virginia and Maryland campaigns, carried on a long struggle with sea power. He almost won.

The two facts that stand out above all others in the history of the American Civil War are the military genius of Lee and the naval superiority of the North. Yet these facts have not received the attention from historians that they deserve. A whole literature has been devoted to Lee's tactical genius or his penchant for winning battles. But little attention has been given to his strategic genius—his capacity for seeing the war as a whole.

THE naval superiority of the North is likewise conceded but seldom understood. The major deficiency in Civil War history has been the failure to analyze these two major strategic forces of the war—Lee's genius and the naval superiority of the North—in their relationship to one another.

Such a study will be attempted here within the framework of one battle, a relatively minor action in scope, but, to me as a naval officer, one of the decisive battles of the American Civil War.

Admiral Hayes is a well-known consultant on naval history. Before his retirement, Admiral Hayes was on the faculty of the Industrial College of the Armed Forces, Fort Leslie J. McNair, Washington, D. C.

I refer to the naval, or rather "fleet-against-fort" action on May 15, 1862, at Drewry's Bluff, ten miles below Richmond on the James River. It was an action between a hastily erected battery and two ironclads. The total casualties on both sides were less than forty men.

Drewry's Bluff was a decisive battle because it set the stage and shaped the pattern of the land war in Virginia. From it followed Second Manassas, Antietam, and Gettysburg. This small action lengthened the war at least two years by postponing the day when it would be settled where it finally was settled—on the banks of the James and Appomattox rivers.

Selecting this Battle of Drewry's Bluff as a case study of military genius versus sea power gives the opportunity for calling attention to a type of naval action which, while not unique to the American Civil War, did to a large extent dominate it. This is the "fleet-against-fort" type of action—Union fleet against Confederate fort. There is only one well-known naval action of that war which cannot be included in that category—the battle between the KEARSARGE and the ALABAMA.

On the other hand, under the heading of "fleet against fort" we can include, in addition to Drewry's Bluff, Port Royal, Forts Henry and Donaldson, Island No. 10, New Orleans, Vicksburg, the whole Charleston campaign, Mobile, and Fort Fisher— and even the battle between the MERRIMAC and MONITOR. Compare if you will the immediate and long-term results of these actions with the bloody standoffs of Shiloh, Murfreesboro, Fredericksburg, and the Wilderness.

THE fleet-against-fort actions were naval: for the Union, to gain control of navigable waters; for the Confederacy, to deny such control. The whole blockade came within the category of fleet against fort and so did the struggle for the rivers which formed the Union lines of supply.

Naval officers, in many cases, were responsible for the forts of the Confederacy either in a command or advisory capacity. Denied service afloat, their ordnance specialty was invaluable here.

Northern officers, on the other hand, had to fight their ships, not on the high seas where they had been trained but up rivers; between bluffs, head on without being able to turn; through mine fields; and, worst of all, among shoals where grounding meant destruction or capture.

Strategy has been defined as the military use of geography, and since this is a strategic study, the geography of Virginia—the area of operations—is all important. Two geographical features dominate any map of that State. The first of these features is Chesapeake Bay and its four rivers: Potomac, Rappahannock, York, and James.

These rivers lead into the heart of Virginia, one of them to the door of its capital, and the side that could control these rivers would have the strategic and logistic advantage. This was the stark fact that confronted Robert E. Lee when on April 22, 1861, he was made Commander in Chief of the military and naval forces of Virginia.

His first act, therefore, was to direct and supervise the erection of batteries in the approaches to Norfolk, along the James River, at Gloucester Point on the York, and on the Potomac at Aquia Creek, then the terminus of the Richmond and Fredericksburg Railroad.

The second dominating feature of Virginia geography is the Shenandoah Valley, forming an area of maneuver as acceptable to the soldier as Chesapeake Bay to the sailor. The Shenandoah Valley provides an avenue to Washington and the North but not to Richmond and the South.

IT was however on Chesapeake Bay that the drama of the war in Virginia opened. The Confederate capital was to be stormed not by the land route from the north which Lincoln preferred but by the water route from the east as McClellan wanted. The York and the James Rivers would form the lines of supply.

McClellan planned this amphibious maneuver without consulting the Navy Department. Just as he was about to start, however, something happened to upset it all. The ironclad MERRIMAC which the Union Navy had known about for six months came out from Norfolk into Hampton Roads on March 8, 1862, to sink two wooden frigates and run three more aground. The next day occurred the classic battle with the MONITOR.

This event revolutionized naval warfare, but, more important at the time, it forced McClellan to face some naval facts of life. He now requested protection from the Navy for his water movements. Gideon Welles, the Secretary of the Navy, countered by asking him to capture the city of Norfolk with its important navy yard. This evidently was not feasible. At the same time the Confederate batteries at Yorktown and Gloucester Point prevented access to the York River while the MERRIMAC denied him the James.

"Did breaking the Federal blockade enter Lee's mind during the Gettysburg campaign? Perhaps, for had he reached the Susquehanna and Delaware Rivers he would have cut the entire supply of anthracite coal to the Union Navy whose blockading squadrons required over a thousand tons a day."

There was no place for the army of over 100,000 men to go but Fort Monroe and be cooped up in the narrow strip of swampy land southeast of a line from Yorktown to present Fort Eustis along Warwick Creek. This line was then held by Gen. John B. Magruder with only 15,000 Confederates.

McClellan, ignorant of Magruder's weakness, started a month's preparation for a siege of Yorktown from the land side while the Navy settled down to wait for the MERRIMAC to come out again.

In the meantime, telegrams demanding more action, more results, kept coming from Washington. They were signed "A. Lincoln."

Finally on the first day of May, McClellan was ready to begin his siege of Yorktown, but the Confederate commander Joseph E. Johnston, did not give him the chance to become another George Washington. The whole Warwick line was abandoned and with it the whole lower Peninsula. The York River was open to the Union Navy.

This was the scene when Abraham Lincoln and Comdr. John Rodgers of the Navy stepped upon the stage. Rodgers, a bouncy, brazen character, already had achieved some fame in the war. Son of the 1812 commodore, he had been present when Norfolk Navy Yard was abandoned and burned by the Federal forces the year before. He and Capt. Horatio G. Wright of the Engineers, later commander of the VI Corps in Grant's Army, had attempted to blow up the drydock but only succeeded in getting themselves captured.

Rodgers was the first naval officer sent to the Western rivers, but he was too strong a character to get along with Frémont who asked for his relief. He returned east in time to accompany Flag Officer Du Pont in the expedition against Port Royal where he had the opportunity to raise the first Stars and Stripes on South Carolina soil.

In December 1861 he initiated the operations that finally led to the surrender of Fort Pulaski at the mouth of the Savannah River. He took command of the GALENA, a prized command, on April 25, 1862.

This ship was built in Mystic, Conn., the second of three experimental ironclads. The others were the MONITOR, built in New York, and the NEW IRONSIDES, the best of the three, built at the Cramp yard in Philadelphia.

The GALENA was classed as a screw steamer, ironclad. Her sloping sides were covered with horizontal 3-inch strips of iron plating. She was 210 feet long, displaced about 900 tons, and had a draft of 14 feet. She mounted two Parrott 100-pounder rifles on a center line and four 11-inch Dahlgren guns, two in a broadside.

Rodgers was thrilled with his new command and the opportunities it might give him. The day he received his orders he wrote to his wife:

"IS not the news glorious . . . at the present moment my prospects are as bright as anyone's in the Navy. An army of 130,000 men await my touch to launch them on the capitals of the rebels. I shall probably be the first to try ironclads against fortifications. It is a great chance."

Two days later he wrote that he wished to try the experience of passing the batteries. His superior officer, Flag Officer Goldsborough, however, decided to keep the GALENA at Hampton Roads where she would be available with the MONITOR to meet the MERRIMAC when the Confederate ironclad should again come out.

Rodgers did not like this decision. He wrote his wife that he was tired of waiting at anchor. John Rodgers thought himself a lucky man, but like most such men he believed in making his own luck where he could. The opportunity came on May 6, 1862.

He was ashore at Fort Monroe taking a walk and inquiring about the news when he learned that the President had arrived with the Secretaries of War and the Treasury. It was ten o'clock in the evening and Rodgers accompanied a colonel whose duty it was to confirm the news.

The President was in bed, but this did not daunt Rodgers. After being introduced, he quickly told the President that there was a great opportunity for a naval movement up the James and explained how it could be done, stating that in war opportunities do not wait.

LINCOLN, who had come to Hampton Roads to stir things up, immediately approved. He sent for Gen. John E. Wool, the Army commander at Fort Monroe. Then Lincoln, Stanton, Chase, Wool and his staff ("to hold the ink bottles," in Rodgers words) proceeded aboard the flagship where orders were prepared to send Rodgers with the GALENA and two gunboats up the James despite the fact that the MERRIMAC was still a major threat to the Union Navy and McClellan's Army.

Norfolk, however, was abandoned in the next few days and the MERRIMAC was scuttled on May 11th. The Confederates then lost control of the lower James River, never again to regain it. Rodgers with his ships were already in the James but how long he would have remained there if the MERRIMAC reached that river as was intended is an interesting speculation.

The GALENA had been aground for thirty-six hours and the two wooden gunboats with Rodgers were no match for the Confederate squadron in the upper James or for the batteries along the river's banks. However Flag Officer Goldsborough, now freed of the MERRIMAC threat, could reenforce him with the MONITOR and the iron NAUGATUCK which mounted another 100-pounder Parrott rifle.

Rodgers with his reenforced squadron proceeded up the river, trying to find fourteen feet of water for his GALENA. He was a good hydrographer, and getting up the James with incompetent pilots and no navigational aids was an accomplishment in itself. Both he and Goldsborough were now confident the squadron would reach Richmond. Farragut, after all, had gotten to New Orleans just a few weeks before.

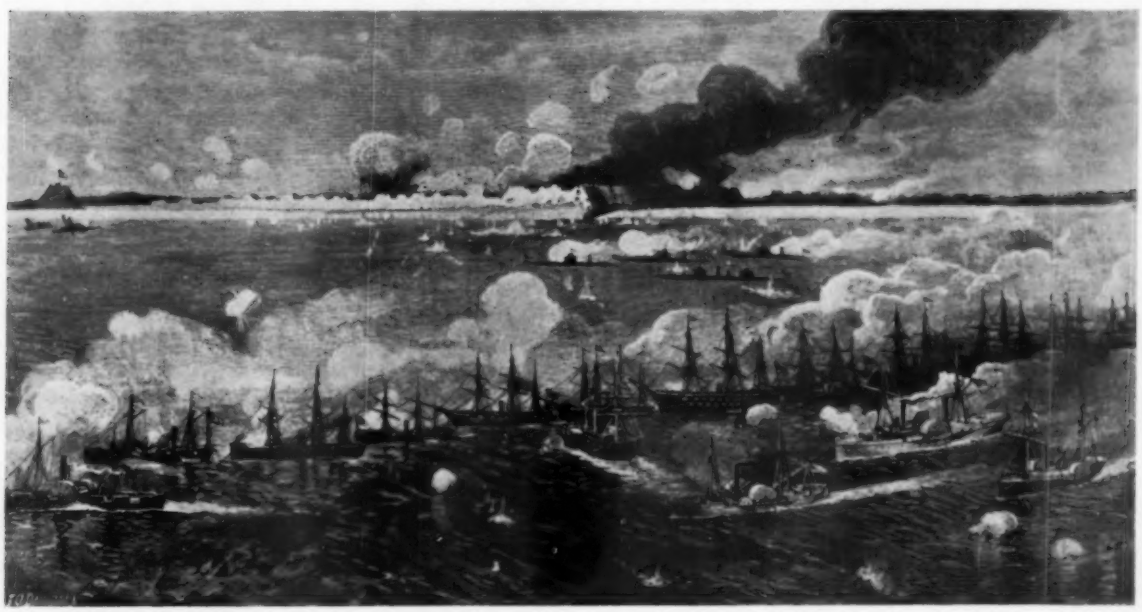
What were the Confederates doing to defend the James River approach to Richmond? Up to this time they had done little. Drewry's Bluff had been early recognized as a strong land point on the river, but the power of the MERRIMAC had given them too much confidence. Now the MERRIMAC was gone, a Federal naval squadron was approaching the city, and a Federal army was in sight of its church steeples.

THE Confederate Navy struggled desperately to make up for lost time. For two days the crews of its James River Squadron and the MERRIMAC, together with the local artillery company under Captain Drewry who owned the property on which the fort was being constructed, worked unceasingly in mud, exposed to rain, without shelter, and with scanty rations. They succeeded in mounting five guns—three 32-pounders and two columbiads.

A battery was ordered to Chaffin's Bluff across the river and the banks were lined with riflemen, instructed to pick off the ships' gun crews, especially those in the ironclads.

Daylight of May 15th revealed the Union squadron in the stretch of river below the bluff. Rodgers wrote his wife about it the next day:

In the final "fleet-against-fort" action, the Union Navy bombards Fort Fisher, closing the port of Wilmington.



"I ran within eight miles of Richmond and there found three separate barriers formed of piles and sunken vessels, the channel only as wide as the vessel's length, the banks lined with sharpshooters and a battery of heavy guns on a hill, 200 feet high, to protect the barrier. We anchored as near the barrier as I deemed right to go, swung the vessel across the channel with a hawser and opened fire.

"Our experiment with the GALENA was fully tried—oblique shot, direct shot, and deck shot; the Rebels demonstrated fully that she is penetrable. They killed thirteen men and wounded eleven. The batteries on the Rebel side were beautifully served and put their shots through our side with great precision. The GALENA did most of the fighting—her sides look as though she had an attack of smallpox."

THE battle had begun at 7:45 a.m. The MONITOR joined the GALENA in the attack, but the guns in her turret could not be elevated to reach the battery on the bluff and she had to drop back to where the other gunboats were shelling at a range of 1,400 yards. Gen. Robert E. Lee witnessed it all from Chaffin's Bluff across the river.

Two guns were temporarily dismounted, but by 11 a.m. the GALENA had expended almost all her ammunition and was so badly hurt that Rodgers made a signal to discontinue the action. The squadron dropped down the river to City Point, now called Hopewell.

The Confederates were liberal in their praise of Rodgers. One observer wrote:

"The attack on Drewry's Bluff was, on the part of the GALENA, I think, one of the most masterly pieces of seamanship of the whole war. . . . She steamed up within seven or eight hundred yards of the bluff, let go her starboard anchor, ran out the chains, put her head inshore, backed astern, let go her stream anchor from the starboard quarter, hove ahead, and made ready for action without firing a gun" (William H. Parker, "Recollections of a Naval Officer"; New York, 1883, p. 279).

John Taylor Wood, himself an outstanding officer of the Confederate cause, states in his article in "Battles and Leaders," Volume I, that had Commander Rodgers been supported by a few brigades at City Point or above, Richmond would have fallen. Rodgers himself wrote the next day in his official report:

"On the James an army can be landed within ten miles of Richmond on either bank. We command City Point and are ready to cooperate with a land force in an advance on Petersburg."

The cautious McClellan was not the man to rise to this opportunity. Rodgers' recommendation had to await another two years and a man named Grant. But the lessons of Drewry's Bluff were not lost on Robert E. Lee.

McClellan, safe at Harrison's Landing and licking his wounds from the Battles of the Seven Days, allowed the Confederate commander the time to do what was so badly needed. Works that could defend Richmond and Petersburg against amphibious attack up the James River were now built. Drewry's Bluff was to be the keystone of this defense.

When all was in order, Lee struck at Second Manassas. With this battle he commenced a series of offensives far from the reaches of sea power. With the help of the Shenandoah Valley he was able to threaten Washington constantly. He thereby kept the larger Army of the Potomac pinned down for two years on the defensive protecting the Union capital instead of conducting an offensive which, with the help of the Union Navy, could have destroyed the Confederacy.

Lee's strategy of holding the right while forcing the Union center and left was dependent an another feature of Virginia geography which is not mentioned in any Civil War history. This is the falls of the Potomac above Washington, D. C., beyond which a Union gunboat could not go. The gunboats, not the ironclad monitors, were the expression of sea power to Confederate generals, and it was the gunboats' batteries that were the dread of Confederate soldiers. But no gunboats could bar Lee's passage across the upper Potomac.

Second Manassas, Sharpsburg, Chancellorsville, Gettysburg—all the battles of importance in Virginia in the next two years—were fought west of a line drawn on a map from the falls of the Potomac to Drewry's Bluff. The sea power of the North had a limitation which Lee never forgot—its potency, mobility, and freedom of action could only reach a gunshot beyond the navigable waters.

DID breaking the Federal blockade enter Lee's mind during the Gettysburg campaign? Perhaps, for had he reached the Susquehanna and Delaware Rivers he would have cut the entire supply of anthracite coal to the Union Navy whose blockading squadron required over a thousand tons a day.

Lee's military genius, with help from the geography of Virginia, gave Southern political leaders two years in which to save something for the Confederacy. Their statesmenship was too weak to reap from his harvest of victories. By the summer of 1864 it was too late.

After bloody Cold Harbor in May 1864 he shifted his army across the Peninsula and the James and placed it before Petersburg. Once more as in McClellan's day the base of supplies was moved from White House on the Pamunkey River to the James, but this time it was at City Point.

Lee countered with his Shenandoah strategy of the left to relieve the pressure which sea power again was putting on his right. He sent Jubal Early with the remnants of Stonewall Jackson's II Corps to sortie from the Valley. Washington was again in danger, but Grant sent the VI Corps overnight by water from Petersburg, and Wright's veterans marched fresh and ready off transports at Washington's 7th Street wharves at about the time Early's tired troops reached the outskirts of the city. Lee's last strategic trump had been played.

Adm. David D. Porter, in the last of the "fleet-against-fort" actions, captured Fort Fisher in January 1865 and closed the port of Wilmington, last in the Confederacy. Lee now lost his supply line and his outlet to Europe. In a few months the Petersburg defenses were broken, and Richmond had to be abandoned. With it, in April 1865, went Drewry's Bluff, last stronghold of the Confederacy. Sea power had prevailed.

Defense Highlights: Monthly Review and Outlook

• **Ballistic Missile Defense.**—Nike Zeus—the Nation's only antimissile missile under development, is an Army Ordnance project. It is pictured on the front cover of this issue.

The problems of defense against ballistic missiles has baffled engineers and scientists for over five years, yet no magic weapon has been proposed. In the interim Army Ordnance has persistently fought to keep its Nike Zeus alive. It is a system that stems from the fifteen years of experience of the Army-industry teams that brought out Nike Ajax, Nike Hercules, and the advanced Nike Hercules.

In the face of howls of rage from the budgeteers over the estimated $10 billion cost and unbelievers in the effectiveness of the proposed Army system, the Army has boldly pushed its Nike Zeus. So here in the "sizzling sixties" there is no ionic, cosmic, nuclear, or high-frequency cure-all weapon to bat down enemy ICBM's—but we do have Nike Zeus.

In a recent progress report, Maj. Gen. Horace F. Bigelow, Deputy Chief of Army Ordnance, announced that since the project was established in February 1957 basic components have been developed and tested, a large 3-stage propulsion unit almost perfected, and acute acquisition and accurate signaling and computing equipment brought to an advanced stage. Mathematical analyses of simulated attacks by ICBM's show the concept to be sound, although some scientists remain skeptical.

Sufficient funds finally have been authorized to perfect quantity-production techniques for these electronic components not presently available from industry.

Testing facilities are in use at White Sands Proving Ground with others being installed in the Atlantic Missile Range, Point Mugu, and the Kwajalein Islands. Full-range overwater tests are slated for Point Mugu, and Nike Zeus will be launched from Kwajalein against Atlas ICBM's fired from California. These shots will prove whether the system's analyses were correct. In the meantime, concurrent testing, training, and planning are being conducted within the funds available to ensure the earliest completion of an operational system in the event it is finally approved.

General Bigelow states: "If carried through to deployment we believe that Zeus could protect a large segment of the country's war-industry potential, safeguard millions of people, and protect a good part of the retaliatory capability."

• **NATO Goes to Sea.**—The armed forces of the countries allied under NATO have been engaged in comprehensive land and sea training exercises from north of Norway to the Dardanelles. While NATO army forces in Scandanavia and West Germany were combating the "aggressor," NATO naval forces in the North Atlantic were conducting exercise Sword Thrust that included air support of the ground forces from carriers at sea.

The first phase of Sword Thrust, in which 65 ships participated—American, British, Canadian, Dutch, French, and Norwegian—included carrier aircraft sorties, repelling attacks by "enemy" submarines and aircraft, and refueling at sea. In the last day, 190 simulated atomic strikes were made on land targets in northern Europe by British and American carrier jet aircraft.

In the second phase of Sword Thrust, carriers off Norway and in the Bay of Biscay provided atomic strike support for ground forces in Norway and West Germany on the assumption that it was D-day plus 10 and most landplanes were out of action. Missions were assigned by NATO air force headquarters.

Concurrently, Danish and West German patrol craft and minesweepers were maneuvering in the lower Baltic and other combined NATO naval forces held exercises in the Mediterranean, the Black Sea, and English Channel.

This triennial series of exercises was hailed by Adm. R. L. Dennison, Supreme Allied Commander, Atlantic, as the most impressive ever conducted. He noted that since the program was planned months ago it was coincidental that the United Nations were meeting. He said, "It was not planned as a saber-rattling demonstration but comes at a time when this demonstration of how well we can work together is needed."

• **Minuteman Moves Ahead.**—Minuteman—the Air Force medium-sized ICBM—is scheduled for prototype flight testing before the year is out. Progress reports from all development areas are gratifying: silo and static engine tests, guidance checkout on rocket sleds, and practical tests of railway routing have been completed in less time than anticipated.

A recent review of each one of the thousands of components that will go into the missile system revealed that no major alterations are required. Thus Minuteman is expected to be operational in 1962 as planned, with the first three squadrons to be located at Malmstrom Air Force Base, north of Salt Lake City.

Although Minuteman will be smaller and lighter than the giant Atlas and Titan ICBM's, thanks to its solid-propellant engines, it will have a 6,300-mile range and pack a terrific nuclear wallop.

• **Summertime Down South.**—Naval and scientific forces are heading for Antarctica to start their "summer" explorations. "Deep Freeze 1961," the sixth operation, involves

about 9 ships, 30 aircraft, and 3,000 men. The projects this year include work on an atomic power station at McMurdo Sound scheduled for completion in 1962, initial excavating for a 15-building camp under the snow at Byrd Station, and an overland track trip to the South Pole 800 miles from Byrd Station.

The 198 scientists and Navy men who spent this winter in the Antarctica will be replaced by a similar unit numbering 43 when winter closes in.

• **Coordinating the Space Effort.**—Military and civilian space programs are now coordinated at the Defense Department-National Aeronautics and Space Administration level by a board chairmanned jointly by Dr. Herbert F. York, Director of Defense Research and Engineering, and Dr. Hugh L. Dryden, Deputy Administrator, NASA.

This Space Coordinating Board, replacing a previous more cumbersome council and committee, will meet bimonthly to review plans, exchange information, and reduce duplication to a minimum.

Serving on the Board are two members at large—Richard S. Morse, Army Director of Research, and Dr. Robert C. Seamans, Associate Director, NASA—and panel chairmen to specialize on launch vehicles, unmanned space craft, manned space flight, ground environment, supporting research, and aeronautics. Panel chairmanships are equally divided between NASA and the Defense Department.

Brig. Gen. R. D. Curtin, formerly Director of Missile and Satellite Systems, U.S.A.F. Headquarters, indicated some of the differences between military and civilian problems in connection with space-vehicle development. Civilian scientific personnel are relatively permanent; military checkout and launching personnel will be constantly changing.

The Midas warning satellite and Samos surveillance satellite systems call for several vehicles in orbit, properly spaced, requiring great precision to replace a "dead" vehicle, whereas scientific space explorations do not demand such split-second timing. Of course NASA will have similar problems when it acquires the ability to assemble platforms in space.

Another military need will be the usual demand for long life in orbit to reduce costs. Both agencies are continuing their efforts to effect savings by developing recoverable first-stage boosters.

• **Chemical Warfare and the Future.**—The American answer to the threat of Communist gas warfare was partially revealed at the first press conference held at Dugway Proving Ground, Utah, the U. S. Army Chemical Corps testing center for chemical-biological-radiological (CBR) weapons and protective devices.

With knowledge that the Communist forces are extensively equipped for CBR warfare, the Army is expanding its own CBR program to provide defenses against possible Soviet attacks. It is also developing offensive weapons to deter the Communists from initiating this form of warfare.

The demonstrations at Dugway, commanded by Col. David Armitage, emphasized the wide selectivity of weapons available to a commander. Some would incapacitate an enemy for minutes or hours to permit overrunning him. Others are capable of lethal results, even before an enemy normally would know that he was under attack. Both forms minimize destruction of the target areas.

The Dugway tests conducted for the press included a few artillery shells fired upon typical field fortifications. Within seconds, the goats and pigeons tethered within them died, although the defense works themselves were essentially undamaged.

Sparky, a mongrel canine test veteran, was once again painlessly paralyzed by gas in another test. Untreated, the paralysis would have lasted several hours, but a hypodermic antidote returned Sparky to his normal friendly friskiness in a few seconds.

Brig. Gen. Fred J. Delmore, commander of the Chemical Corps Research and Development Command, also pointed out the research conducted on delivery systems, including artillery shells and missiles, aircraft, and ICBM's.

Dugway heavily emphasizes defensive measures against a possible CBR attack. Perhaps the most severe problem is the timely detection of the attack. Thereafter the rapid use of protective masks, clothing, and shelters will minimize casualties. However, thorough training of both military and civilians will be essential if the full deterrent value of CBR weapons is to be obtained.

• **New Industrial College Building.**—President Eisenhower delivered the principal address at the dedication of the new Academic Building of the Industrial College of the Armed Forces at Fort Leslie J. McNair, Washington, D.C., on September 6, 1960.

The President, a 1933 graduate of the College, emphasized the ever-increasing importance of the mission of the Industrial College to keep our military leaders knowledgeable of the capabilities of science and industry. Noting the impact of the physical sciences upon the military art today, the President expressed his confidence that new knowledge would be imparted to our leaders to assure national security.

• **Depreciation of "Scrap" Material.**—An aggravating aspect of Defense Department financial management is the matter of dollar recovery on surplus material. Self-appointed critics, legislators, and glib-talking economists berate Defense authorities for the small percentage return on scrap.

Very few of them yet have learned that the $25-million-dollar carrier of the late 1930's or the old Flying Fortress originally costing $220,000 must be carried on the Government books at their initial cost until they are scrapped as required by our laws.

The military receive endless complaints because on an obsolete tank only two per cent is recovered on the original investment. Forgotten is the fact that it had been worn out serving the Nation's defense for many years.

A commercial vessel or airliner on the other hand would have been depreciated to zero in the same time span, and the owner would have been proud to show a gain when his old wreck was sold for scrap.

Words Are Powerful Weapons

An Editorial

THE spectacle recently enacted at the United Nations headquarters in New York emphasized again the power of words as weapons. When spoken to convey truth, the word is a mighty instrument for good; when uttered—and generally with violent gestures—to proclaim falsehood, it is a correspondingly vicious implement of evil. In the one case the message is sincerely aimed at peace; in the other the object is either the prolongation of cold war or the ignition of cold war into the inferno of mortal battle.

Meanwhile, the gullible and unsuspecting are fascinated by bullies, the correspondents grind out the copy for home and foreign headlines, the broadcasters flood the airways with their unending "features." And thus, allegedly, the cause of peace is enhanced.

In reality, it seems to us, we in America are collectively in the position of the Emperor Nero who "fiddled while Rome burned." Not long after Nero, the grandeur that the Romans had built for over six centuries was no more.

It is not amiss, then, that this journal, which is devoted to the progress of weapons in the United States, pause to remind its readers that the one weapon which is not surpassed in its power by even the nuclear warhead is *the word*. The case was well stated several years ago by Rear Adm. Lewis L. Strauss, when, as Chairman of the U. S. Atomic Energy Commission, he addressed the National Press Club in Washington, D. C.

"From your hale and hearty faces," he said, "I am persuaded that none of you is any the worse for strontium 90, a substance not to be confused with printer's ink. The latter really can be deadly, especially when the fallout is intense. It is not I but you, I venture to think, who deal with the most potent materials—for you can produce mutations in the thoughts, the fears, and also the hopes of all men."

THE word as a weapon came to its more powerful status with the advent of the printing press. Oswald Spengler was correct when he wrote, "Gunpowder and the printing press belong together." From the seventeenth century on the pamphleteers, the journalists, and the marshals of words have been as potent—and often more so—in fomenting war as all the military leaders together.

For the agitator, truth is falsehood, hypocrisy is virtue. It was so in the build-up of popular frenzy preceding our own American Civil War, our Spanish-American War, our involvement in the First and Second World Wars. This same technique when used deliberately to disseminate falsehood and incite the ignorant will most surely lead to a third world war.

Added to the written and spoken word, the latest form of image weapon is television. As is the case with all other weapons, it has its good uses as well as its bad. When used honestly to maintain peace through understanding and cooperation it can be a boon to humanity. As a vehicle for lies, hypocrisy, and agitation, it is as deadly as the most potent nuclear device yet dreamed of.

This method of verbal warfare is also basic in the Communist technique of attack on the credulity of the emotional masses. Lately Communist leaders have been given an opportunity to sell their wares with utter abandon twenty-four hours a day in the halls of the United Nations, on the streets, and in the hotel lobbies of New York, on page after page after page of the newspapers, and incessantly on the radios and television screens of farm and hamlet. The battle of truth versus falsity has never before been more intense in volume or the consequences so weighty.

THE solution, as we see it, is to continue to preach the truth by every available means and on every occasion. Truth and cooperation among honest people must eventually win out. Meanwhile, as all sensible combatants realize, it would be well to roll with the punch and then hit back hard.

Let us keep our defenses strong in all areas—on land, at sea, under the sea, in the air, and in outer space. And our other weapons—words—let us always keep them truthful. Our ordnance weapons will be our last but ready resort in case of Communist attack; our arsenal of words will, as through the ages, assure us and the world that we shall know the truth—and the truth will keep us free.

These simple reflections are the result of the debacle that has been allowed to happen on our shores by permitting the enemies of our country, boldly within our gates, to fire salvo after salvo of attack upon our national morale. Here again the Communist technique has shown its utter disregard for truth, its blatant design to sway the illiterate, its sweeping attempt to mislead the gullible.

The pattern is a repetition of an old one. It was the same during the Munitions Investigation in the mid-1930's when our own defense strength was sadly weakened at the very advent of the Second World War.

The same type of Communist chicanery was at work before, during, and since the Spanish Civil War. Communist double dealing throughout World War II was responsible for the tragic aftermath of that conflict.

These instances of Communist weaponry of words proclaim loudly the power of the word to sway the minds of men and to win victories of vast effect—often without the firing of a single shot.

Truly, as Disraeli said, "people are ruled by words." In the free world with its free speech and free press the lines can never be as tightly drawn as they are in the Communist world with its controlled press and its police state. We had better prosecute the counterattack with determination and with truth—otherwise the only weapons left us will be those that our military arsenals and civilian factories produce. Peace will be assured only through strength—the strength of truth backed by the strength of arms.

America's Production

Program of the Association's Forty-second Annual Industrial Preparedness Meeting to be held on Wednesday, December 7, 1960, at the Waldorf-Astoria Hotel, New York City. Reservation form on request.

PRESIDING

LOUIS POLK

President, American Ordnance Association

Morning Session—9:00 o'clock—Empire Room

SEMINAR: DEPARTMENT OF DEFENSE POLICY AND INDUSTRIAL PRODUCTION

SPEAKER

RUSSELL A. CRIST

Director of the Office of Production Policy, Office of the Assistant Secretary of Defense—Supply and Logistics, Washington, D. C.

SEMINAR: THE ARMY AND INDUSTRIAL PRODUCTION

CHAIRMAN

LIEUTENANT GENERAL JOHN H. HINRICHS

Chief of Ordnance, United States Army, Washington, D. C.

SPEAKERS

MAJOR GENERAL GUNNAR C. CARLSON

Chief, Industrial Division, Ordnance Corps, United States Army

PAUL L. DAVIES

Chairman, Food Machinery and Chemical Corporation, San Jose, Calif.

W. MILLER HURLEY

Vice-President, Winchester-Western Division, Olin Mathieson Chemical Corporation, New Haven, Conn.

WALTER HERR

Western Electric Company, New York, N. Y.

SEMINAR: THE NAVY AND INDUSTRIAL PRODUCTION

CHAIRMAN

REAR ADMIRAL PAUL D. STROOP

Chief of the Bureau of Naval Weapons, United States Navy, Washington, D. C.

SPEAKERS

REAR ADMIRAL J. E. DODSON

Assistant Chief, Bureau of Naval Weapons—Fleet Readiness

HENRY F. ARGENTO

Vice-President and General Manager, Philco Corporation, Philadelphia, Pa.

(Continued on next page)

Of Defense Weapons

JOHN B. HAWLEY, JR.
Chairman of the Board and President, Northern Ordnance, Inc., Minneapolis, Minn.

DR. ERNEST ROBERTS
Assistant Plant Manager, Solid Rocket Plant, Aerojet-General Corporation, Sacramento, Calif.

Midday Session—1:00 o'clock—Starlight Roof

ARMAMENT PREPAREDNESS LUNCHEON

PRESIDING

LIEUTENANT GENERAL BLACKSHEAR M. BRYAN
President, New York Post, American Ordnance Association

ADDRESS

ROBERT W. HENDERSON
Vice-President, Weapons Programs, Sandia Corporation, Albuquerque, N. Mex.

Afternoon Session—2:45 o'clock—Empire Room

SEMINAR: THE AIR FORCE AND INDUSTRIAL PRODUCTION

CHAIRMAN

LIEUTENANT GENERAL MARK E. BRADLEY, JR.
Deputy Chief of Staff, Matériel, United States Air Force, Washington, D. C.

SPEAKERS

MAJOR GENERAL W. AUSTIN DAVIS
Commander, Aeronautical Systems Center, Air Matériel Command, Wright-Patterson Air Force Base, Ohio

J. R. DEMPSEY
Vice-President and Manager, Convair Astronautics, General Dynamics Corporation, San Diego, Calif

DR. NORMAN GROSSMAN
Chief, Equipment Engineering, Republic Aviation Corporation, Farmingdale, N. Y.

HAROLD R. RAYNOR
Assistant General Manager, Missile Division, North American Aviation, Inc., Los Angeles, Calif.

Evening Session—7:30 o'clock—Grand Ballroom

INDUSTRIAL PREPAREDNESS DINNER

TOASTMASTER

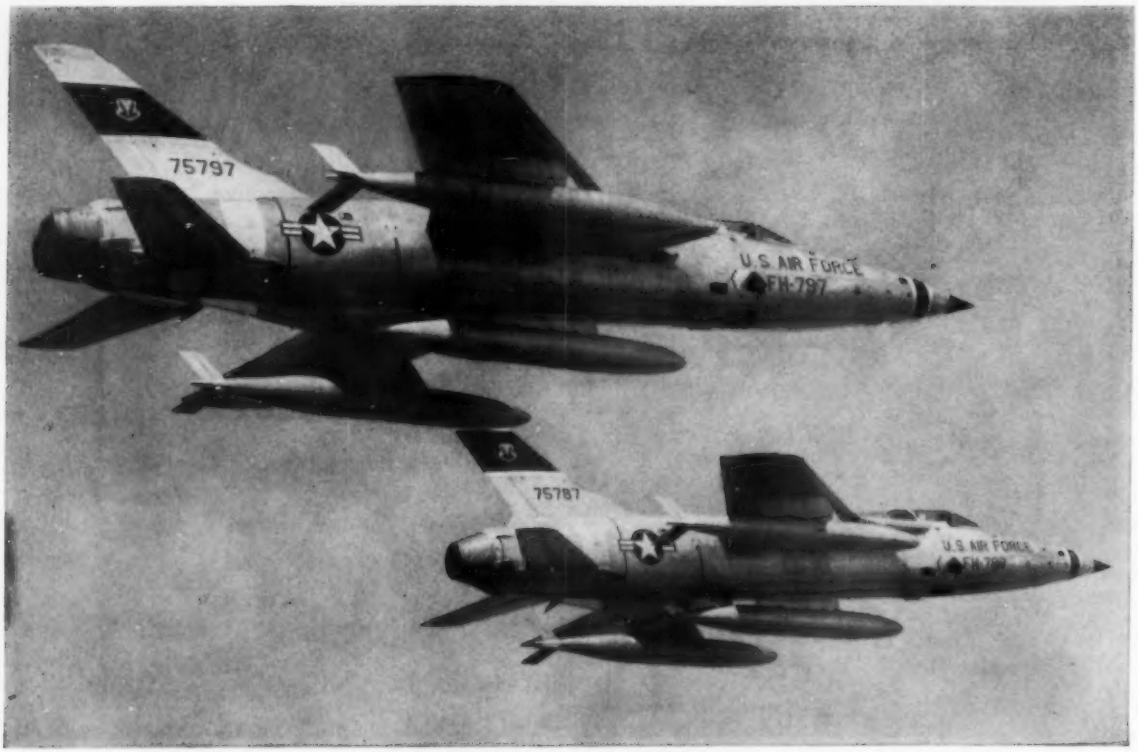
LOUIS POLK
President, American Ordnance Association

ADDRESS

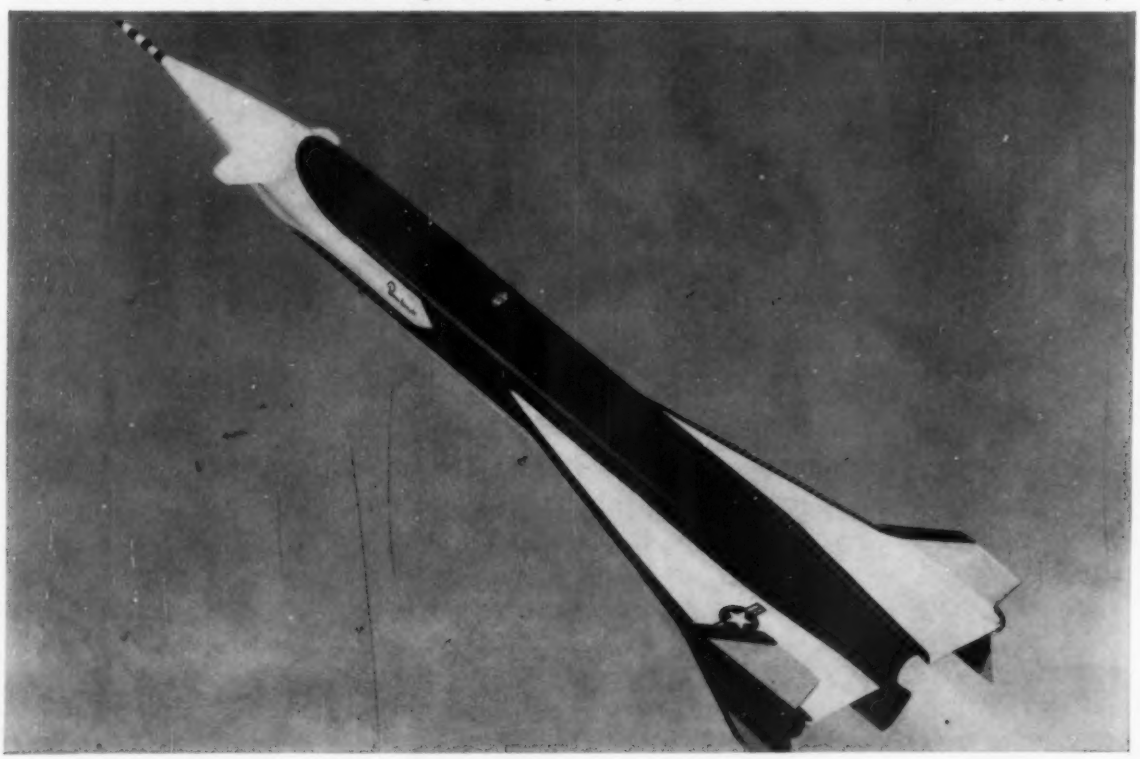
GENERAL THOMAS D. WHITE
Chief of Staff, United States Air Force

AWARD OF THE CROZIER MEDAL TO GENERAL WHITE

Supersonic Weapons and Targets



Known as "reusable guided missiles," the 1,400-mile-an-hour Republic F-105 Air Force jet fighter-bombers above are flying from Florida to California under robot guidance. Their pilots handled the controls only on take-off and landing. Below is Beech Aircraft's KD2B-1 Mach 2 missile target that can operate up to 70,000 feet to simulate enemy aircraft (Navy photo).



ASSOCIATION AFFAIRS

Cincinnati Post Of A.O.A. Awards Harrison Medal To Neil H. McElroy

Few Secretaries of Defense have been in charge of the destinies of our military posture during more difficult "peacetime" periods than Neil H. McElroy who filled the office with distinction and now has returned to the chairmanship of Procter & Gamble Company. In recognition of his outstanding contribution he was the recipient of the Harrison Gold Medal awarded annually by the Cincinnati Post of the Ordnance Association. The presentation took place at the Post's annual meeting before a distinguished audience of Cincinnati industrial and military leaders at the Netherland-Hilton Hotel in Cincinnati, October 4, 1960.

In response to this accolade by the Ordnance fraternity, Secretary McElroy took the occasion to analyze our present military status, and in a most convincing and erudite fashion he told of some of the major problems before the defense establishment and of the steps that were taken regarding our national preparedness in conventional and unconventional weapons.

His remarks, while extemporaneous, are worthy of analysis and study by all students of weapons preparedness. It is the hope of the editors of ORDNANCE that a transcription of the address can be published in the next issue of this journal.

The presiding officer at the meeting was Homer E. Lunken, president of the Cincinnati Post and vice-president of the Lunkenheimer Company. The preamble to the constitution of the Association was read by Graham E. Marx, a director of the Post and president of G. A. Gray Company. Greetings from the national Association and the citation which accompanied the award of the medal to Secretary McElroy were given by Louis Polk, president of the Association and president of the Sheffield Corporation. The medal was presented by Harvey C. Knowles, Sr., A.O.A. vice-president and vice-president of Procter & Gamble Company.

The occasion was in the best Cincinnati tradition where the Ordnance fraternity over many years has performed such notable contributions to defense progress. Among the nearly 500 members and guests who were in attendance at the meeting to honor Secretary McElroy were a number of distinguished industrial leaders of the Cincinnati area who were seated at the speakers' table.

In addition to those already named there were: LeRoy R. Brooks, vice-president and director of the Cincinnati Post and president of the Tool Steel Gear and Pinion Company; Richard R. Deupree, honorary chairman, Procter & Gamble Company; Robert S. Gruver, former president and present director, Cincinnati Post, and vice-president of Armco Steel Corporation.

Also, Walter W. Tangeman, former president of the Cincinnati Post and president of the Cincinnati Chamber of Commerce; Harry S. Robinson, director, Cincinnati Post, and former chief of the Cincinnati Ordnance District; Col. Leo A. Codd, executive vice-president, American Ordnance Association; E. Webster Harrison, former treasurer and director, Cincinnati Post, and partner, Harrison & Company.

Also, Harold R. LeBlond, former president and present director, Cincinnati Post, and president, Cleveland Automatic Machine Company; Col. William A. Evans, secretary-treasurer, Cincinnati Post, and commanding officer, Cincinnati Ordnance District; Keith H. Hoffman, vice-president, Cincinnati Post, and assistant to the general manager, Allison Division, GMC.

Also, Howard J. Morgens, president, Procter & Gamble Company; David A. Meeker, director, Cincinnati Post, and president, Hobart Manufacturing Company; Robert B. Harrison, son of the late Charles L. Harrison; the Rev. Francis J. Moore, D.D.; John D. O'Brien, former president and director, Cincinnati Post, and general manager of Inland Manufacturing Division, GMC.

Also, Brig. Gen. W. W. Lapsley, Ohio River Division, Army Engineer Corps; Charles L. Harrison, son of the late Charles L. Harrison; and L. W. Scott Alter, former president and director, Cincinnati Post, and president of American Tool Works Company.

Louis Polk, A.O.A. president, left, reads citation accompanying the Harrison Award to Neil H. McElroy, former Secretary of Defense, center. Harvey C. Knowles, vice-president of the Association, right, presented the Harrison Medal to Mr. McElroy. The honor was conferred by the Cincinnati Post.

Special Committee Formed By A.O.A. On Recoilless Rifles And Ammunition

As a result of a request by Lieut. Gen. J. H. Hinrichs, Chief of Ordnance, U. S. Army, a special committee on recoilless-rifle and ammunition systems has been formed within the American Ordnance

Association. This committee, which will hold its first meeting on November 15th at Frankford Arsenal, Philadelphia, Pa., will work closely with Col. A. R. Cyr, commanding officer of the arsenal. He has been designated manager for the Army's recoilless systems.

To provide a capability of experienced people for this committee, three representatives from each of the following Divisions will be nominated by their respective chairmen: the Artillery Division; Bomb, Warhead and Artillery Ammunition Division; and the Small Arms and Small Arms Ammunition Division. Among those named for the committee were Alfred R. Metzger, Bethlehem Steel Company, Bethlehem, Pa.; Gerald V. Middaugh, Koppers Company, Baltimore, Md.; and Col. R. R. Studler, Washington, D. C.; Mart H. Wagner, Fred Affrunti, and Dr. C. S. Cummings, Remington Arms Company, Bridgeport, Conn. Subsequent meetings will be announced later.

Yankee Post Celebrates Thirty-Fifth Anniversary With Trip And Dinner

The thirty-fifth annual meeting of the Yankee Post was celebrated by a trip to Andover, Mass., to visit the Merrimack Valley Works of Western Electric Company followed by a dinner meeting at the Andover Country Club on October 6th. New England members, 250 strong, drove in from all parts of the Post area to participate in the ceremonies.

The host company treated the crowd to a well-planned tour of the component production of the devices that make mass production of telephones and television possible. It proved to be an interesting revelation of the latest application of automation in the electronics industry.

At the dinner meeting the Rev. Henry P. King, Jr., of All Saints Church, Georgetown, Mass., delivered the invocation. The business meeting was conducted by Post President John H. Gannett who received the report of the treasurer and in his accounting praised the thirty-five years of devoted service on the Industry-Ordnance Team by the Yankee Post of the A.O.A.

The guest of honor and principal speaker was Capt. K. M. Tebo, head of program evaluation in the Special Projects (Polaris) Office of the Bureau of Naval Weapons. Captain Tebo used film and slides to present an account of the Navy's Polaris program that was right up to the minute with views of the latest operations in the missile-firing submarine, GEORGE WASHINGTON, as well as recent progress in developing the longer-range 1,500-mile missile.

Guests at the speakers' table included: Post Vice-President James P. W. Davidson, vice-president, Saco-Lowell Shops; Col. Maurice L. Driscoll, commanding officer, Boston Ordnance District and a director of the Yankee Post; Carl F. Carlstrom, director, Yankee Post, Carlstrom Pressed Metal Company; John J. Shaughnessy, superintendent of industrial and labor relations, Western Electric Company; Harry N. Snook, assistant works manager for operations, Western Electric Company; Post Vice-President Ashley A. Farrar, assistant vice-president and director of government contracts, Raytheon Company; Post Secretary-Treasurer John C. Dieselman, Morse-Smith-Morse Company; and James Murphy, Post vice-president.

Planning And Programming Committee Meets To Discuss A. O. A. Objectives

The second meeting of the Planning and Programming Committee was held at the Army-Navy Club, Washington, D. C., on September 14th and 15th, when members of the Committee met to study the objectives and capabilities of A.O.A. technical Division operations and map plans for the coming year.

Everett L. Baugh, Cadillac Motor Car Division, GMC, Cleveland Ordnance Plant, Cleveland, Ohio, general chairman, A.O.A. technical Divisions, opened the meeting and described its purpose. A.O.A. Vice-President Henry N. Marsh, Wilmington, Del., extended greetings to the group, and Maj. Gen. Edward P. Mechling, A.O.A. staff director for technical operations, presented a draft of a letter concerning human engineering which will be sent to Division and Section chairmen.

A report of the ad hoc subcommittee on technical publications was then presented by Dr. G. R. Tatum, Vitro Laboratories, Silver Spring, Md., and a discussion was held on the billion-dollar business of these publications, the lack of an industry association for establishing standards of high quality essential for cost evaluation, the failure to obtain required quality because of lack of standards, and the need to obtain uniform standards. The problems of uniformity in format in these publications was noted as well as the general approach to content and the need to assure that the publications meet the requirements of the user.

General Mechling then discussed the desirability and effectiveness of liaison personnel in major Government agencies concerned with weapons and cited the assistance given by Henry Handler, Office, Chief of Ordnance, outlining problems that can arise when such assistance is not available. He said that efforts will continue to establish liaison offices appropriate to the organizational structure of the services.

The importance of A.O.A. publications in keeping members informed on the status of ordnance also was noted by General Mechling, who stressed the need for appropriate material, particularly for ORDNANCE magazine, and asked for comments on the effectiveness of all A.O.A. publications.

Committee members then reported on the activities of their respective Divisions in the areas of reliability, quality control, and qualification testing. Comments on these topics were made by Dr. Philip H. Burdett, Remington Arms Company, Bridgeport, Conn.; Dr. G. R. Tatum, Vitro Laboratories, Silver Spring, Md.; H. J. Schrader, Radio Corporation of America, Moorestown, N. J.; Dr. Herbert A. Nye, Cornell Aeronautical Laboratory, Inc., Arlington, Va.; and Rear Adm. M. F. Schoeffel, U.S.N. (Ret.), General Precision, Inc., Washington, D. C. Mr. Baugh noted the emphasis placed on reliability in combat vehicles during the past two years and the pressing need for improved major subassemblies and components.

The reorganization of the Fire Control Instrument Division was next considered. It was decided that this Division will work primarily with the Frankford Arsenal, Philadelphia, Pa., and its functional assignments will be artillery fire control, combat-vehicle fire control, and infantry and general fire control.

One of the highlights of the 2-day meeting was the dinner on September 14th at which high representatives of Government and key officers of the Association spoke. A.O.A. President Louis Polk, Sheffield Corporation, Dayton, Ohio, briefly emphasized the importance of the work of the technical Divisions, while Col. Henry N. Marsh, A.O.A. vice-president, Wilmington, Del., and Leo A. Codd, executive vice-president of A.O.A., discussed the importance of Association publications.

Admiral Schoeffel commented on the operations and problems of a large A.O.A.

Division operating with all the services, and Dr. Tatum described smaller Division operations with only one service, emphasizing the value of these small groups.

C. H. Madsen, Naugatuck Chemical Division, U. S. Rubber Company, New York, N. Y., discussed the operations of the A.O.A. technical support Divisions and the capabilities they could offer to commodity Divisions and to Government agencies.

Mr. Baugh concluded the discussions by noting that he estimated that the Government was not using the Divisions at a maximum of over-all capability. He then urged service personnel to take advantage of consultant services which are available without cost.

At the business meeting on September 15th, W. M. Gourley, Philco Corporation, Philadelphia, Pa., chairman of the Value Engineering Committee, submitted a report on his Committee at the initial morning session. He discussed the origin of the Underwater Ordnance Division and its work with the Bureau of Naval Weapons and noted the current recognition of value engineering by all military services and the need for incentives for effective contractor support.

Discussion next centered on organization activities for a special committee for recoilless-rifle and ammunition systems that is being formed at the request of the Chief of Army Ordnance. It will work closely with Frankford Arsenal, Pa., where the first meeting will be held in November. Nominations for this committee will be made from the Artillery Division; Bomb, Warhead and Artillery Ammunition Division; and the Small Arms and Small Arms Ammunition Division.

General Mechling noted that letters would soon go out requesting that Division and Section chairmen submit statements of their organization's capabilities and a description of work that their units are willing to undertake. With this in hand, he said, it should be possible to improve liaison with Defense agencies and to better inform new military personnel of A.O.A. capabilities.

Another highlight of the 2-day meeting was a dinner which was attended by representatives of Government weapons agencies and key officers of the Association.

Maj. Gen. H. F. Bigelow Addresses First Meeting Of Toledo Chapter

The newest Chapter of the Ordnance Association's growing list of local organizations was inaugurated at Toledo, Ohio, on October 5, 1960. Representing one of the most important industrial areas in the United States, the Toledo group was formally established as a Chapter of the Cleveland Post.

The occasion was noteworthy in many respects. The honor guest and principal speaker, Maj. Gen. H. F. Bigelow, Deputy Chief of Army Ordnance, described the phenomenal progress in the Army's development of the antimissile missile, the Nike Zeus. The presentation was one to bring reassurance to all who are beguiled by unfavorable criticism of the defense establishment in this vital area.

The subject of his talk was "Technology and the Threat." The editors of ORDNANCE intend to publish it in an early issue of this journal and urge its study by all fellow citizens.

Also noteworthy was the fact that the chairman of the meeting and the newly elected chairman of the Chapter is John E. Martin, president of the Dana Corporation, Toledo. Mr. Martin served as an assistant to the Chief of Ordnance in World War II where his administrative ability was instrumental in solving many an "unsolvable" problem and where results were attained in areas thought to be impossible.

A third factor in the impressiveness of the occasion was the presence of Lieut. Gen. Levin H. Campbell, Jr., a director of the Ordnance Association, who was Chief of Ordnance of the Army from 1942 until the termination of World War II. General Campbell, in congratulating the members of the new Chapter, also urged them to enlist the cooperation and the support of the younger executives and engineers of industry upon whom so much of future success in weapons preparedness depends.

Nearly 400 members and guests were assembled to hear General Bigelow's address and to participate in the inauguration of the new Chapter. The invocation at the dinner was given by the Rev. George Wigfield, pastor of the Pilgrim Congregational Church. The preamble to the constitution of the national Association was read by Leo A. Codd, executive vice-president.

Among the special guests were Col. B. B. Abrams, former commanding officer of the Rossford Ordnance Depot and his successor, Col. H. J. Marker, and the following members of the board of directors of the new Chapter:

Duane Stranahan, vice-president, Champion Spark Plug Company; Rear Adm. Robert W. Cary, U.S.N., (Ret.), Toledo Marine Terminals, Inc.; W. W. Knight, Jr., chairman, Toledo-Lucas County Port Authority; and J. Preston Levis, chairman, Owens-Illinois Glass Company.

Also on the board of directors are Robert H. Davies, president, the Electric Autolite Company, and George T. McNichol, Jr., president, Libbey-Owens-Ford Glass Company.

All in all the new Chapter got under way with an inspiring inaugural ceremony and bids fair to be one of the Association's strong adjuncts.

Executive Board, Packaging And Handling Division, Meets In Washington, D. C.

The Executive Board of the Packaging and Handling Division met on September 13th at Washington, D. C., to take official action on consolidating the Container Section of the Bomb, Warhead and Artillery Ammunition Division within the appropriate sections of the Packaging and Handling Division.

It was generally felt that the Container and Materials Testing Section overlaps both the Container Design Section and the Materials Section and that its scope should be broadened to include all packaging methods, processes, and techniques. It also was felt that the work of the Container Design Section should not be confined to design.

The proposed organization of the Division would include the following three sections: Containers Section, Materials Section, and Methods Section. Harvey C. Simms, Zero Manufacturing Company, Silver Spring, Md., has been named deputy Division chairman.

Citadel Post Meets To Plan Program Of Visits And Approve Membership Rules

The cadets of The Citadel, who make up one of the most alert Posts of the A.O.A., went into action on September 20th shortly after the college opened. The meeting was conducted by Cadet Samuel R. Bird, Post president, who called for approval of standards of membership and reported on plans for the coming season to visit near-by military establishments and the Aberdeen Proving Ground, Md.

The Citadel Post standards of membership require that a cadet have a good academic average, a contract for commissioning in one of the armed services, and that he be consistent in attending meetings.

The agenda was completed with the

viewing of a color film on the life of Comdr. H. W. Gillmore, a heroic submarine skipper lost in World War II. It was an appropriate subject since the Post recently had visited the submarine tender named for Commander Gillmore.

Annual Golf Tournament Of Washington Post Draws Big Crowd To Share Many Prizes

Ordnance Association golfers packed the Indian Spring Country Club near Washington, D. C., for the annual trophy tournament on September 19th, crowding both the Chief and Valley courses. Many members from other posts were on hand to compete for the two top prizes and participate in the festivities. The over-all program was organized by M. C. Richmond, president of the Washington Post, and his general chairmen, Ned O. Kraft and W. R. F. Adams, with Henry R. Long in charge of the many details of the golf arrangements and Melvin B. Harris caring for the reception and dinner.

After the last foursome checked in late in the afternoon, scores were quickly adjusted and winners proclaimed as follows: The U. S. Steel Corporation's Fairless trophy for low gross of 74, William Brownrigg, III; the International Harvester Company's McCaffrey trophy for a low net of 68, William Walker.

The golf committee and the golfers were especially indebted to the thoughtfulness of General Motors' Washington office which supplied a station wagon to gather extra caddies from other country clubs. For once there were enough "bag toters" to meet all demands.

In addition to the trophies each champion received a special prize, and prizes were awarded the first three runners-up. Awards also were presented for the longest drive, closest ball to the pin and other special achievements. Still under consideration is a prize for the man who made a hole-in-one—but on the eleventh green, having driven from the fifteenth tee!

In the afternoon, horseshoe-pitching contests were in full swing with J. Bruce Parker as organizing chairman. S. C. David was the champion, carrying off a prize in both the singles and doubles.

Golfers and horseshoe pitchers joined with late arrivals for a general reception and informal dinner in the clubhouse where every one who attended received a handy pocket tool as a memento of the occasion.

The excitement and interest over this affair was enhanced by the generosity of the many members and organizations that donated some of the golf prizes and all the door prizes.

Special thanks were voted for the many committee members who assisted the various chairmen to make this year's outing such a pleasant, successful event.

General Greene Is Guest Of Honor At Annual Meeting Of Lone Star Post

Lieut. Gen. Wallace M. Greene, Jr., Chief of Staff, U. S. Marine Corps, was guest of honor at a reception and annual meeting of the Lone Star Post on Friday, October 5th. The general's appearance at this meeting at the Ridgelea Country Club near Fort Worth concluded his 2-day inspection trip through industrial plants of central Texas while he was the guest of Wallace Joyce, Post president, and a vice-president of Texas Instruments, Inc.

Following the invocation by Dr. William P. Barnds, rector, Trinity Episcopal Church, Fort Worth, Mr. Joyce welcomed the members and their ladies and introduced the distinguished guests in the audience and at the speakers' table. Especially welcomed were the officers of the Texas A. & M. Chapter led by Cadet Lieut. A. J. Bahme, Chapter president, and G. F. Huber, president of the Texas Post with headquarters in Houston.

When the meeting was opened, Fred B. McKimball, Post vice-president, announced the recommendations of his nominating committee for new Post officials, and they were unanimously accepted. Thereupon Mr. Joyce introduced Blake C. Caldwell, the newly elected president and president of Jet Research Center, Arlington, Tex., who assumed the duties of his office on the spot by introducing the guest of honor.

General Greene, to the great delight of the audience, departed from the usual theme of A.O.A. meetings. He did briefly note that Marines had excellent weapons and expressed his appreciation for the service rendered by the A.O.A. in this field. Then he launched into a stirring account of the manner in which his Corps accepts the young recruit, average age 18, with many shortcomings and in sixteen weeks makes him into a splendid fighting Marine.

After his address, General Greene was presented with the traditional Texas citizenship certificate and the Stetson, boots, and personalized branding iron that mark him as a Texan. The presentations were made in masterful style by Col. H. Ross Jordan, the Post's representative on the national A.O.A. Council.

The new Lone Star Post officers in addition to Mr. Caldwell, are: T. E. Myers, North American Aviation, Inc., vice-president; A. B. Thompson, Chance Vought Aircraft, Inc., vice-president; Reginald L. Robinson, Jet Research Center, secretary-treasurer. The new directors are W. F. Joyce, F. B. McKimball, and D. P. Strauss.

Planning Group Decides Reorganization Of Fire Control Instrument Division

A meeting to discuss support of fire-control activities at Frankford Arsenal was held on September 7th at the University Club, New York City, where reports from the arsenal representatives on current work and interest of that establishment in the field of fire control were presented. As a result of this meeting and its studies, the Planning and Programming Committee, which met in Washington, D. C., on September 14th and 15th, decided that reorganization of the Fire Control Instrument Division was warranted.

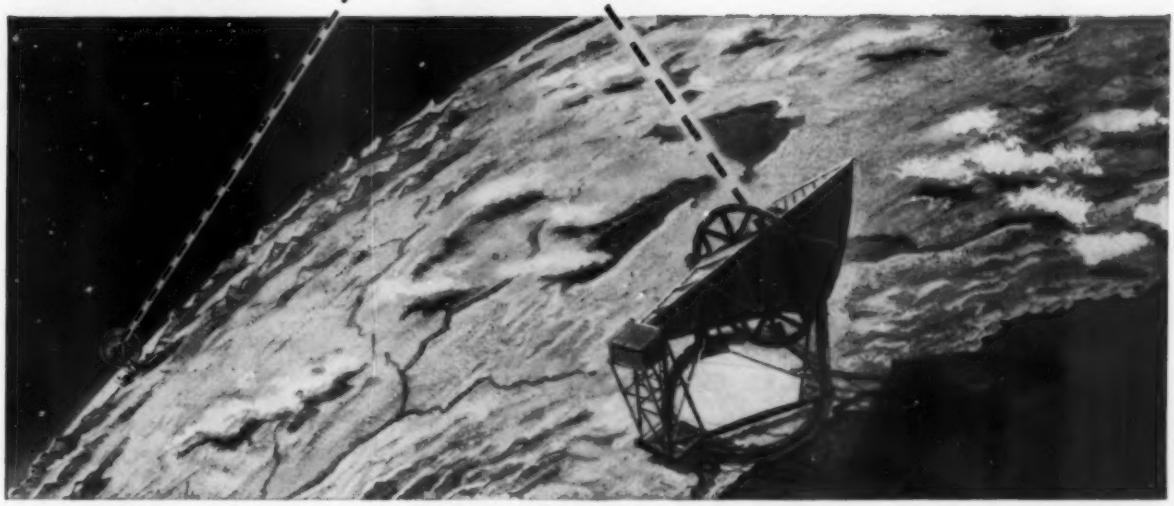
The meeting was opened with reports from the Frankford Arsenal representatives on the current work of the Arsenal in the field of fire control. Dr. Morton Chwalow of Frankford discussed some of the electro-optical approaches, including the application of television, while Col. A. R. Cyr, commanding officer of the Arsenal, emphasized the need for A.O.A. support on the basis of major programs and indicated that the current emphasis on specialized components, as the Division is now organized, will not be effective in the future.

Dr. Wilmer L. Barrow, Sperry Gyroscope Company, Great Neck, N. Y., chairman of the Division, suggested that it might be best to dissolve the present Division and reassign the Fire Control Section. He also proposed that the Test Range Instrumentation Section be placed within the Missiles and Astronautics Division and that other sections be placed in the existing technical-support Divisions.

As a result of this meeting, the Planning and Programming Committee au-

FIRST PHONE CALL VIA MAN-MADE SATELLITE!

"Project Echo" satellite went into a near-perfect circular orbit 1000 miles high, circling the earth once every two hours. Its orbital path covered all parts of the U. S.



BELL TELEPHONE LABORATORIES BOUNCES VOICE OFF SPHERE PLACED IN ORBIT A THOUSAND MILES ABOVE THE EARTH

Think of watching a royal wedding in Europe by live TV, or telephoning to Singapore or Calcutta—*by way of outer-space satellites!* A mere dream a few years ago, this idea is now a giant step closer to reality.

Bell Telephone Laboratories recently took the step by successfully bouncing a phone call between its Holmdel, N. J., test site and the Jet Propulsion Laboratory of the National Aeronautics and Space Administration (NASA) in Goldstone, California. The reflector was a 100-foot sphere of aluminized plastic orbiting the earth 1000 miles up.

Dramatic application of telephone science

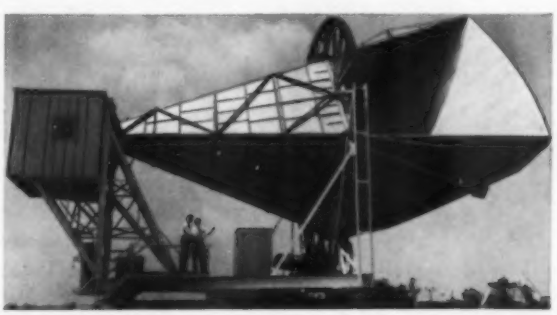
Sponsored by NASA, this dramatic experiment—known as "Project Echo"—relied heavily on telephone science for its fulfillment . . .

- The Delta rocket which carried the satellite into space was steered into a precise orbit by the Bell Laboratories Command Guidance System. This is the same system which recently guided the remarkable Tiros I weather satellite into its near-perfect circular orbit.

- To pick up the signals, a special horn-reflector antenna was used. Previously perfected by Bell Laboratories for microwave radio relay, it is virtually immune to common radio "noise" interference. The amplifier—also a Laboratories development—was a traveling wave "maser" with very low noise susceptibility. The signals were still further protected from noise by a special FM receiving technique invented at Bell Laboratories.

"Project Echo" foreshadows the day when numerous man-made satellites might be in orbit all around the earth, acting as 24-hour-a-day relay stations for TV programs and phone calls between all nations.

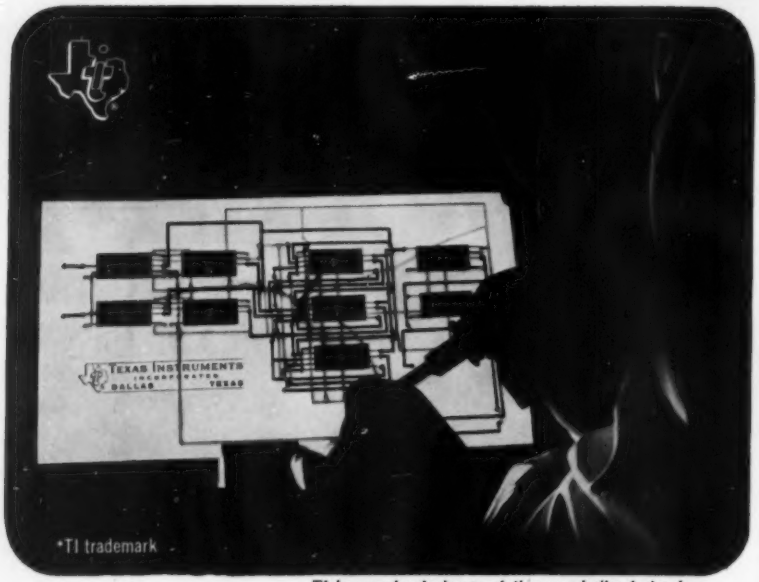
This experiment shows how Bell Laboratories, as part of the Bell System, is working to advance space communication. Just as we pioneered in world-wide telephone service by radio and cable, so we are pioneering now in using outer space to improve communications on earth. It's part of our job, and we are a long way toward the goal.



Giant ultra-sensitive horn-reflector antenna which received signals bounced off the satellite. It is located at Bell Telephone Laboratories, Holmdel, New Jersey.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



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Association Affairs (Contd.)

thorized, with the approval of Col. Henry N. Marsh, Wilmington, Del., A.O.A. vice-president, a reorganization of the Fire Control Instrument Division. It was generally agreed that a new technical-support Division devoted to the state of the art, quality, reliability, and production of specialized components would be justified. If such a Division is established, it was felt, the Instrument Precision Ball Bearing Section, the Instrument Jewel Bearing Section, and the Optical Section would properly belong there. The Mechanical Instruments Section would be absorbed within the three Sections devoted to fire control itself.

Louisiana Post Helps To Dedicate Nike Battery, Hears Wernher von Braun

The Louisiana Post, under the energetic leadership of its president, Frank S. Kelly, Jr., and his enthusiastic officers and directors, sponsored a full day of activity on September 30th in Shreveport. The daytime event was the dedication of the Stonewall Nike Hercules Battery, south of Shreveport, manned by the 5th Missile Battalion, 562nd Artillery, who were the hosts.

In the evening the Post held its annual dinner meeting where Dr. Wernher von Braun, Director, Marshall Space Flight Center, Huntsville, Ala., was guest of honor.

Out at the Stonewall Battery, members and guests assembled at 10 a.m. for orientation and a slide presentation of the Nike Hercules in action conducted by Lieut. Col. Alfred L. Toth, commander of the missile battalion. They then observed the inspection of the honor guard and flag ceremony and heard the invocation by the

Louisiana Post Treasurer E. A. Merklein, Sr., left, receives A.O.A. medallion at Post meeting. Dr. Wernher von Braun, space scientist, right, was guest speaker.

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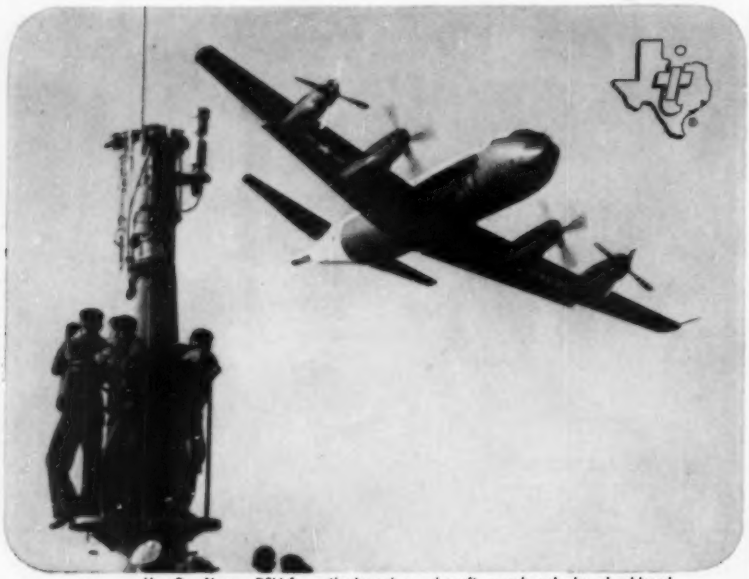

U. S. Navy P3V-1 antisubmarine aircraft produced by Lockheed — equipped with TI-built AN/APS-80 surface search radar, AN/APA-125A indicator, and additional gear (nomenclature classified).

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THE WORLD OVER
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THE WORLD'S FINEST
TRACING CLOTH

Association Affairs (Contd.)

Rev. M. B. Majolie, S.J., president, Jesuit High School.

The colors were raised and momentarily lowered in honor of the Army men of DeSoto and Stonewall parishes who were killed in World War II and the Korean war and whose names are inscribed on a plaque at the base of the flagstaff.

Hon. Overton Brooks, Congressman for this Louisiana district and Chairman of the House Science and Astronautics Committee, introduced Lieut. Gen. Robert J. Wood, Commander, Army Air Defense Command, Colorado Springs, Colo., who delivered the dedication address. General Wood explained the capabilities of the Nike Hercules and cautioned that "exploding technology has brought forth weapons of intercontinental reach and vast destructive power." To combat this threat he pointed to the Nike Zeus missile under development by the Army for knocking out enemy ballistic missiles.

Luncheon was served to the group of 260 at the battery followed by a tour of the missile sites.

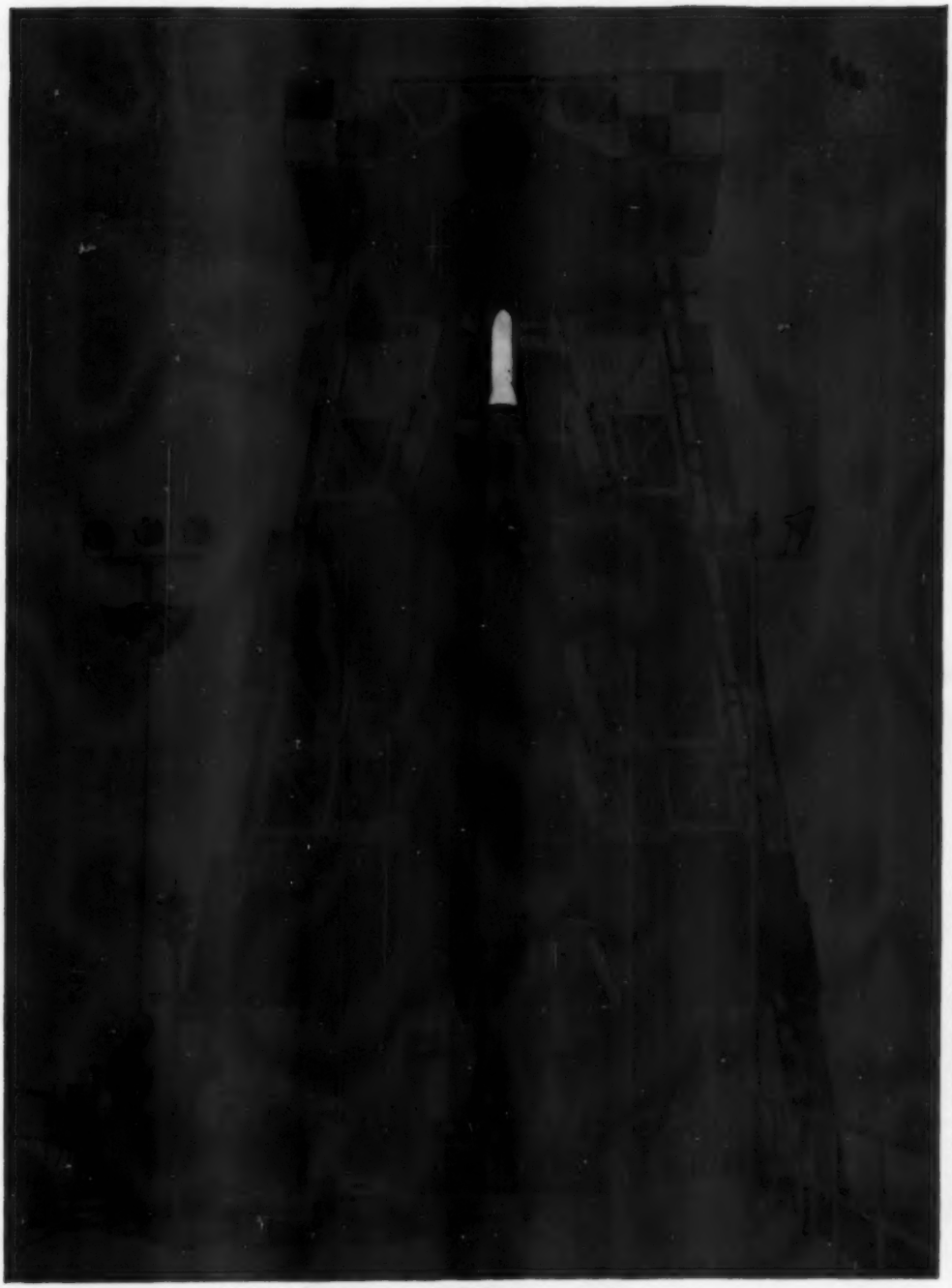
For the dinner in the Crystal Ballroom of the Washington-Youree Hotel, the day's crowd was increased to almost 400 and included many distinguished guests. Present with Dr. von Braun from the Marshall Laboratory were Dr. Oswald H. Lange, Bart Slattery, Max Smith, Eric Neubert, Russell Kyle, and J. L. Parker. Mayors and Chamber of Commerce presidents were: Mayor Clyde E. Fant, Shreveport; Mayor Jake Cameron, Bossier City; Mayor Frank Norman, Minden; Mayor J. H. Lewing, Mansfield; Mayor J. A. Dunnam, Jr., Benton—all in Louisiana; and Mayor Frank Green, Marshall, Tex.

The presidents of the Chambers of Commerce were: Leonard Phillips, Shreveport; Gladstone Lynch, Bossier; Claude West, Minden; C. B. Yarbrough, DeSoto; and Vivian Hackney, Marshall.

Also present were many distinguished officers of the Army Air Defense Command, North American Defense Command, and Barksdale Air Force Base.

Post President Frank S. Kelly, Jr., opened the meeting with the pledge of allegiance to the Flag followed by an invocation by the Rev. J. Lawrence Plumley, rector, St. Mark's Episcopal Church. Mr. Kelly then recounted the outstanding service career of Colonel Toth, who is also a director of the Post, and called on him to introduce the guests.

The names of officers and directors for the coming year were presented by Col. T. L. Gaines, U.S.A. (Ret.) chairman of the nominating committee, and were unanimously elected. All officers were reelected and the new directors are: Maj. Don Catherman, O. H. Clark, A. A. Rowland, Samuel M. Sharp, and Col. Donald M. Simpson. (*Contd. on p. 376*)



Business end of an Atlas ICBM. Atop this Air Force intercontinental ballistic missile is a compact but tremendously complex re-entry test vehicle. With its instrumented payload, it will hurtle thousands of miles to a pin-point target in a matter of minutes. It will soon be on the assembly line at Avco, where operational re-entry vehicles for Titan and Minuteman are already being produced.

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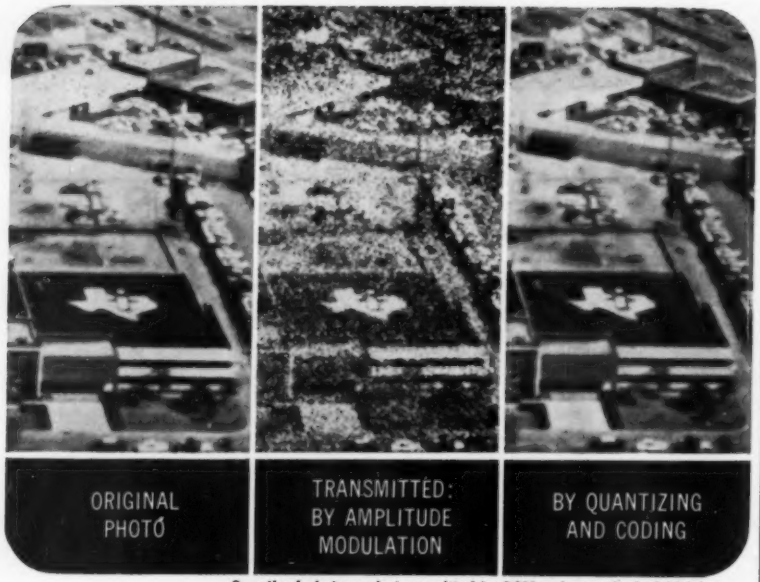

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Association Affairs (Contd.)

The special citation and medallion awarded to Ernest A. Merklein, Sr., by the Association's national board of directors was presented by Capt. J. M. P. Wright from A.O.A. Headquarters. The citation read in part:

"Patriot and respected civic leader, Mr. Merklein has devoted his capabilities and energies for more than a decade to further the ideals of the American Ordnance Association. His wise counsel, skilled guidance, and friendly manner have helped to make the Association a dominant organization in Louisiana for arousing the interest of its citizens in armament preparedness."

Dr. von Braun received a rousing welcome after he was introduced by Congressman Brooks. The famous space scientist talked primarily about the Saturn project, the million-pound-thrust launching vehicle under development in his laboratory, and illustrated his discussion with descriptive slides.

"It will be approximately 185 feet high and will weigh about 1,160,000 pounds fueled and poised for lift-off from the pad," he said. "Of this weight, almost 1,000,000 pounds will be fuel and oxidizer." This first stage of the Saturn will be powered by a cluster of eight kerosene and liquid-oxygen-burning engines.

Dr. von Braun explained technical operations on the consumption of fuel by the rocket and plans for second and third stages, also being developed. "This first version of the Saturn will be able to lift 20,000 pounds into a low orbit," the scientist predicted, "and should be capable of landing 1,000 to 2,000 pounds softly on the moon."

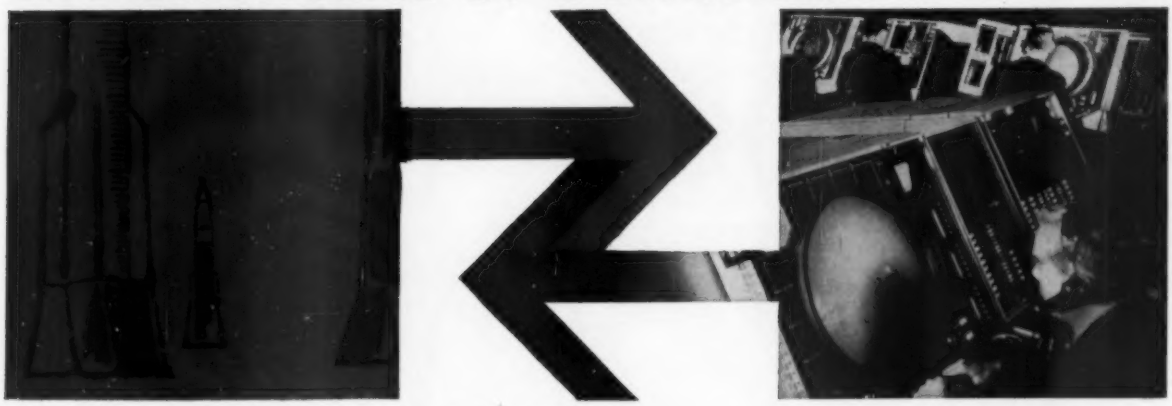
He listed other purposes of the future Saturn. He said space refueling stations may be necessary for a manned flight to the moon and return to earth. This system would be required, he explained, because the crew would need a lift-off thrust of about 12,000,000 pounds, while the present Saturn thrust is less than 2,000,000.

Concluding, Dr. von Braun pointed out the need for probing space. "Man has learned to live and multiply so proficiently that if he keeps it up another 500 years, he won't have a place to sleep, because there will be standing room only on this planet," he said.

Special Committee Under Dr. G. R. Tatum To Survey Technical Publications

As a result of an ad hoc committee formed in the late summer, headed by Dr. G. R. Tatum, Vitro Laboratories, Silver Spring, Md., a special committee has been formed in A.O.A. which is exploring the field of technical publications,

the elements of Command Control:



Data Acquisition and Application
The measure of any command control system is time. Success depends on how fast the system can close the loop between detected action and counter-action. Command control begins with data acquisition and ends with data application. Here, IBM's experience encompasses subsystems for the acquisition of information from distant and varied sensing devices, and for the presentation of refined data to commanders for military action.

Data Communication
High-speed networks that link command control computers require facilities to assemble and direct masses of data. Time is important. IBM data communication capabilities are evident in systems such as SABRE, a real-time activity control network; and INFORMER, a rugged, mobile field control center. These systems employ communication techniques involving real-time data channels, data conversion and message switching.

Data Processing and Control
Information must be quickly reduced and refined through computer processing to prepare it for command decision. Here again time is paramount. IBM has solved special data processing problems with standard systems such as the 709, installed for space vehicle orbit computations, and advanced systems such as the AN/FSQ 31V, in production for the Strategic Air Command Control System.

...all systems capabilities of IBM

IBM solutions to command control requirements range in scope from antisubmarine warfare studies to Air Force control systems like project 473L, and from the compact INFORMER to STRETCH, the world's largest computer. From study to implementation, IBM has proved its ability to solve the problem of time in all three elements of command control systems.

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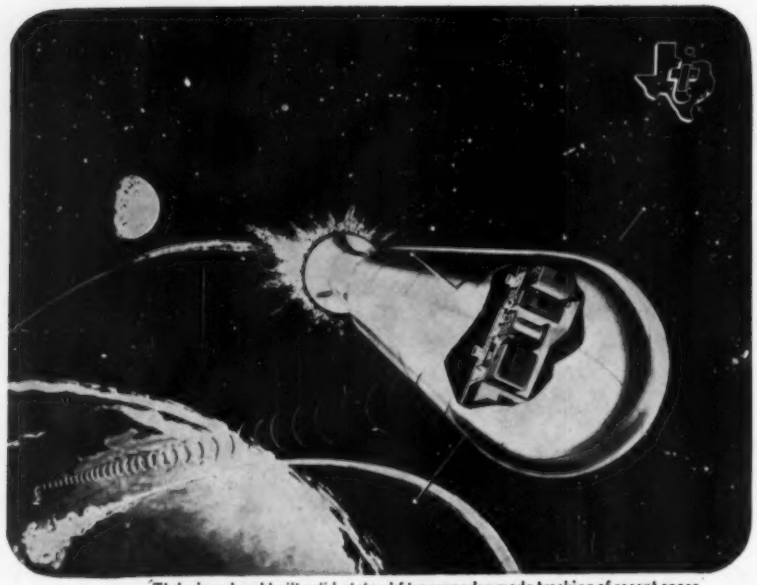

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Association Affairs (Contd.)

including operations and maintenance manuals.

The purpose of this group is to see what A.O.A. can do about improving quality and providing education in this area.

Other members of the original ad hoc committee were Dr. Philip H. Burdett, Remington Arms Corporation, Bridgeport, Conn., and Frank R. Kadie, Chrysler Motors Corporation, Washington, D. C.

Los Angeles Post Opens New Season With Dinner At Aeronautical Institute

The lively schedule of the Los Angeles Post was launched on September 14th with an informal dinner meeting at the Institute of Aeronautical Sciences Building, Los Angeles, Calif.

Dr. Aaron B. Nadel, psychologist for the environment operation of Tempo, a division of General Electric Company, so entranced his audience of almost 200 that that questions flowed for over an hour after his talk. His subject was, "What Makes a Security Risk?"

Dr. Nadel first discussed a wide variety of personalities and the background factors that affect personality. He explained the relationships among personality perception, memory, and testimony and speculated on the background of some recent defectors to Communist countries.

Post President Aubrey Austin announced that the remainder of the schedule called for a day at sea in the U.S.S. KEARSARGE on October 10th, a field trip to the Jet Propulsion Laboratory of the National Aeronautics and Space Administration in early November, and the annual dinner in February 1961.

Container Design Section Holds Quarterly Meeting At Burbank, California

The Container Design Section, Packaging and Handling Division, held its quarterly meeting at Burbank, Calif., in early summer with approximately twenty-five members and many consultants and guests in attendance. Chairman Harold A. Kilmer, North American Aviation, Inc., Los Angeles, Calif., presided.

A discussion was held on methods to effect closer liaison with other technical organizations concerned with container design and specifications and it was felt that coordinated effort to avoid duplication and conflict must be attained. R. B. Bodoh, led this discussion.

Plans also were made for a survey of containers which was highlighted by a report from A. F. Weissenberger, also of North American Aviation, who told where detailed information might be obtained.

Puget Sound Members Tour Sage Installation At McChord Air Force Base

Puget Sound Post members were treated to a tour of the Sage installation at McChord Air Force Base on September 16th followed by a dinner meeting at the Officers' Club. The party was greeted by Col. James F. Reed, base commander, who explained the over-all functions of the base which is a key center in the air defense of the Northwest.

The Sage (semiautomatic ground environment) installation was explained by the operators at the various consoles and scopes and the members were shown how fighter interceptors and missile batteries would be coordinated in case of an enemy bomber attack.

At the evening meeting, new Post officials were introduced and future programs discussed.

Capital Cities Post Visits West Point For Meeting, Sees Opening Football Game

Capital Cities Post members enjoyed a change of pace when instead of their usual dinner meeting they journeyed to West Point to visit the Military Academy and witness the opening football game between the Cadets and the University of Buffalo.

Led by Post President William Stuart, the party of 300 inspected the Ordnance School, the Armament Museum, and many other activities and witnessed the parade preceding luncheon and the football game.

Welding Section Steering Committee Holds Meetings In Philadelphia And Newark

The Steering Committee of the A.O.A. Welding Section held a two-phase meeting in June—one part at the Sheraton Hotel, Philadelphia, Pa., and the other at Newark, N. J., each about a week apart.

H. L. Ingram, Air Reduction Company, Washington, D. C., chairman of the committee, commented at the outset of the first meeting on the over-all viewpoint the committee should employ in handling problems presented by the Chief of Army Ord-

(Continued on p. 381)

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These thirty-five hundred weapons specialists are organized into eight A.O.A. Commodity Divisions and six Technical Support Divisions with a total of seventy Sections, covering essentially the entire field of weapons systems and supporting equipment. In addition to the Divisions and Sections, Special Committees have been established on Value Engineering, Recoilless Rifles and Ammunition Systems, and Technical Publications.

Divisions, Sections, and Committees meet to keep informed on weapons programs and to take action on technical problems submitted by the armed forces. Guidance for these activities is published in the Technical Operations Manual. Current information and instructions appear bimonthly in INDUSTRIAL PREPAREDNESS. Unclassified technical papers of wide interest from Division meetings appear in either ORDNANCE magazine or WEAPONS TECHNOLOGY.

Members of the Technical Divisions are listed in the Annual Directory. Requirements for Division membership are A.O.A. membership, outstanding technical qualifications, a "secret" security clearance, and available time for participation. Qualified individuals who are interested should write to either the Chairman of the appropriate Section, as listed in the Annual Directory, or to A.O.A. Headquarters.

Through its technical operations, its Post and Chapter activities, and its publications the Association will continue to make every effort to maintain and improve its service to Government weapons agencies.

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nance. In reviewing and discussing these problems, it was the consensus of the committee that the group would indicate to the Department of Defense the problems which could be pursued.

A number of suggestions were made concerning the widening of the scope of activity so as to include the National Aeronautics and Space Administration and encourage greater participation on the part of the Navy and Air Force at the Welding Section and subsection meetings.

Problems submitted were reviewed with the purpose of making possible assignments to the various subsections.

T. C. Smith Becomes Chairman Of Fuze Section; Deputy Chairman Is W. C. Faithorn

Two steering committee members of the Fuze Section, Bomb, Warhead and Artillery Ammunition Division, have assumed new offices. Thomas C. Smith, Daystrom Electric Corporation, Poughkeepsie, N. Y., has been named Section chairman, and Walter E. Faithorn, Jr., Stewart-Warner Corporation, Washington, D. C., is deputy chairman. Mr. Smith takes over from the former chairman, James E. Burke, also of Stewart-Warner, who will continue as a member of the steering committee.

Quality Control Society To Hold 2-Day Conference In November At Baltimore

Technical Division members will be interested to know that the Middle Alantic Region of the American Society for Quality Control will hold a 2-day Aircraft and Missile Division Conference on November 11th and 12th at the Lord Baltimore Hotel, Baltimore, Md.

• **C. V. FLETCHER** of Dallas, Tex., one of the most loyal members of the Ordnance fraternity, died August 6, 1960. He was a charter director of the Lone Star Post of the Association and was well-known throughout the Southwest as owner of the C. V. Fletcher Valuation & Appraisal Company.

Mr. Fletcher became identified with Ordnance activities through service in the Dallas suboffice of the St. Louis Army Ordnance District in the Second World War. After service in the Army Air Corps during World War I, he practiced his profession as an appraiser. He was the first governor of the American Society of Ap-

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Association Affairs (Contd.)

praisers from 1956 to 1959, and served as president of the Dallas Chapter of that organization in 1955.

He took a leading part in the arrangements for the annual meeting of the American Ordnance Association which was held in Fort Worth in 1954. He also participated in the activities of the Lone Star Post until the time of his death. He will be missed greatly by his Ordnance colleagues, especially in the Dallas-Fort Worth area.

• **JULIAN KING SPRAGUE**, president of Sprague Electric Company and a member of the Association for almost twelve years, died September 27th at his ranch in Presidio, Tex.

He was a consultant to the War Production Board from 1943 to 1945, a member of the panel on components of the Research and Development Board in Washington from 1951 to 1954, a member of the steering committee of the research and engineering advisory panel on electronics, and chairman of the advisory group on electronic parts for the Department of Defense.

He also was a director of many industrial and banking concerns and a trustee of several educational and civic institutions.

Throughout the past decade Mr. Sprague and his company have been strong supporters of the Association, participating in the activities of the Capital Cities Post.

• **COL. CHARLES F. MOSHER**, former Chief of the Rochester Army Ordnance District and for many years an officer of the Empire Post of the Ordnance Association, died at his home in Rochester, N. Y., August 3, 1960. He had a long and distinguished career as a leader in the typographical industry, and combined with it an active interest in industrial and military affairs for many years.

His military career began in 1906 when he enlisted in the 3rd Infantry Regiment of the New York National Guard. He became a commissioned officer while serving on the Mexican Border in 1914. His service in the Guard was completed in World War II when he served as battalion commander and executive officer of the 108th Regiment's howitzer company. He was promoted to the grade of colonel before his retirement from active status.

Chairman of the board of the firm of Henderson-Mosher, Inc., he was known throughout the printing industry, having served as president of the Rochester Typothetae. He was cited by the Secretary of the Army in 1959 for patriotic civilian service at the annual meeting of the Empire Post of the Ordnance Association. Colonel Mosher was a director emeritus of the Post.

NEW DEVELOPMENTS

Chemical Rockets

The Army has a new weapons system which fires a salvo of forty-five chemical rockets from the fiberglass tubes in which they are packaged. The rockets can be placed in a launcher, electrical connections made, and fired by a rocket crew in less than twenty minutes. Stabilized fins, folded to fit in the tubes, open automatically when the rocket is fired. An explosive charge disperses the chemical agent carried in the rocket head.

The launcher, developed by the Army Ordnance Corps, is made of aluminum and rests on a tubular-frame carriage. All the individual sections are light enough to be handled and assembled manually. When assembled, the system can be moved short distances by the crew without a towing vehicle. The entire weapon can be transported by helicopter or mounted in a 2½-ton truck.

New Aircraft Radar

A new aircraft electronic system has been developed by Hughes Aircraft Company that enables a fighter-bomber to fly hedge-hopping missions in adverse weather and to avoid detection by darting in below an enemy's radar cover. The system, called Taran (tactical attack radar and navigator), will make it possible for tactical aircraft to operate by electronic control much as all-weather interceptors now do. The system has three basic capabilities:

1. Navigation.—Taran will automatically navigate out to a target and back in any kind of weather, day or night. It continuously shows the pilot his position by a symbol on a moving map displayed on a screen in the cockpit.

2. Air-to-ground attack.—A new high-resolution radar enables the pilot to pick out ground targets through dense fog or overcast.

3. Air-to-air attack.—The system can perform the search and track functions required to locate an enemy aircraft, and it will launch either radar or infrared air-to-air guided missiles.

One of the features of Taran is a "terrain-avoidance" mode. When flying in this mode, the radar "sees" only those objects that are high enough to be dangerous to the aircraft.

"Ground mapping" is another feature designed to aid blind flying. In this mode the radar scope displays a "picture" of the terrain beneath the aircraft so the pilot can orient himself and compare the radar picture to the navigation map display.

New Suit for Moon Man

A 2-piece lunar suit that can also serve as a house has been designed by Republic Aviation Corporation to protect an astronaut engaged in surface activity on the moon during his stay outside a space vehicle. During periods of rest he can withdraw his legs from the lower trouserlike sections and rest or sleep within it.

New suit for lunar explorers.

The suit will incorporate a full range of internal apparatus to provide a complete livable environment. It was conceived as a basic unit which could be adapted, by addition or removal of various sections, to a variety of jobs associated with manned space stations, space reconnaissance, and lunar explorations.

The suit consists of a 2-piece cylindrical aluminum tunic and torso with legs and arms attached. The dome-shaped top section is encircled by a 14-inch-high window, and within the aluminum capsule are a radio communication unit, air conditioning and oxygen supply controls, lifting handles, resting seat, food storage bins, waste storage bins, searchlight control, and electrical power supply.

Ice Fuel Reservoir

Diesel oil—30,000 gallons of it—has been pumped into a huge ice reservoir 100 feet beneath the surface of the Greenland icecap as a possible solution to fuel-storage problems in the Arctic. This gross oil pit, which has no lining of any type, is located at the U. S. Army Engineer Research and Development Detachment Ice Tunnel, Camp Tuto, Greenland.

Storage of the fuel in this large monolithic reservoir of solid ice will in no way detract from its purity or volatility. Since the subsurface temperatures within the ice cavern remain at a constant 17 degrees Fahrenheit, moisture crystals and other extraneous matter will freeze and settle to the bottom. After years of storage the oil will be as pure as the day it left the refinery.

During the winter of 1961-1962, fuel from the reservoir will provide heating and other utility needs for the personnel of the Army Engineer R&D Detachment who will be housed and employed within the confines of the ice tunnel.

Nike Zeus Computer

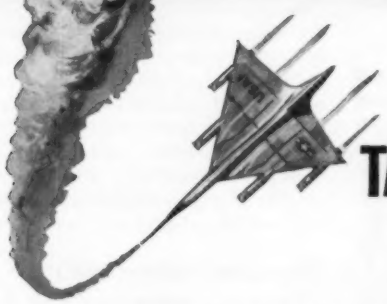
The first prototype model of a target intercept computer for guidance of the Army's Nike Zeus anti-ICBM missile now under development has been installed at the White Sands Missile Range, N. Mex. Designed for speed, accuracy, and reliability, the computer will receive position, speed, and direction of incoming missiles from radar tracking stations to determine the exact trajectory. With this information the computer is able to dictate a precise launching time and issue the necessary steering orders so that the Nike Zeus will intercept and destroy the enemy ICBM.

Through built-in error-detection circuits, the computer continually checks itself to assure it completely performs each operation. If the computer discovers an error, it will give a signal, automatically isolate the error to a specific location, and assist in correcting any faulty calculation.

Computerized Maintenance

A new era in the maintenance of cars, trucks, tanks—in fact of any vehicle—may be beginning. An Army Ordnance research team at the Frankford Arsenal, Philadelphia, Pa., has developed a computerized checkout system which will take the guesswork out of automotive repair, thereby preventing unnecessary repairs and rebuilds. At the same time, the automatic checkout system enhances vehicle reliability by accurately isolating possible sources of trouble before malfunction actually occurs. All of this is accomplished without removing or disassembling any major component. (*Continued on p. 386*)

Shown above is a modified version of the AN/GJQ-9



AIR FORCE SELECTS BENDIX TAPE-CONTROLLED TEST UNIT FOR SKYBOLT MISSILE CHECKOUT

The Air Force Type AN/GJQ-9 Checkout Sequence Programming Set—a universal, automatic programmer-comparator—is now in quantity production at Bendix. It is designed for automatic GO, NO-GO checkout of the GAM-87A Skybolt, an air-launched hypersonic ballistic missile manufactured by Douglas Aircraft Company. In addition, the device—capable of making as many as 100,000 test evaluations—is adaptable to a wide range of other programmed, sequential testing and monitoring operations.

Some functions of the AN/GJQ-9 are:

- **Selection of stimuli control channels for application to system under test.**
- **Regulation of program continuation in accord with measurement and evaluation results, or holding program conditions as directed by tape intelligence and selected operating mode.**
- **Operation of visual and printed read-out devices to indicate test data in accord with selected mode of operation.**

BENDIX SUPPORT EQUIPMENT—TETERBORO concentrates on developing electronic and electromechanical equipment. Systems produced besides checkout devices include adaption equipment, training devices and simulators, and monitoring equipment.

90-MINUTE CONVAIR B-58 CHECKOUT. Still another example of proved Bendix support capabilities is this flight-line computer-on-wheels. Previous flight control system checkout procedures required the time of two men for three days in making *spot* static tests. This automatic Bendix equipment makes 750 static and dynamic tests in 1½ hours. The B-58 flight control system is manufactured by Eclipse-Pioneer Division of The Bendix Corporation.

ANOTHER BENDIX FACILITY: Bendix Support Equipment—South Bend, Indiana, specializes in hydraulic, pneumatic, and mechanical equipment, including missile launchers, erection equipment, power generating and supply systems, and many other related devices.

For answers to your electronic and electromechanical support problems, contact . . .

THE Bendix CORPORATION

BENDIX SUPPORT EQUIPMENT

TETERBORO, N. J.

New Developments (Contd.)

Heart of the system is a digital control computer manufactured by the Librascope Division of General Precision, Inc. The computer has been modified to accept magnetic-tape input and has an input rate of 75 data words of 31-bit length per second.

Included in the checkout system are a voltage-to-digital converter for translating transducer voltage responses into digitial form; a commutator unit capable of handling 240 separate transducer lines; a Flexowriter for interrogation, command input, and print-out; a magnetic-tape storage unit; and accessory equipment for relaying, filtering, amplifying, and switching.

The technique for the checkout system is to (1) interrogate the vehicle with a number of sensing elements (transducers) under both static and dynamic conditions and (2) use logic and computer circuitry to isolate specific mechanical malfunctions.

Bullpup for Thunderchief

The Air Force recently announced it is developing a prototype launcher to allow the air-to-surface Bullpup missile to be added to the F-105 inventory of weapons. The launcher is expected to be located on pylons beneath the wing of the F-105, as it is on the F-100.

The Tactical Air Command presently is using the Bullpup (GAM-83A) guided air missile with a high-explosive warhead. An advanced version, the GAM-83B, will be able to carry either a nuclear or conventional warhead. The missile can be launched by the pilot more than two miles away from the target. A radio link guidance system controlled from the cockpit gives the missile its accuracy. The missile requires little ground test equipment and no preflight missile checkout.

Nike Zeus Facilities

New Army Nike Zeus facilities for advanced testing of the tactical-type Nike Zeus antimissile-missile system, are being constructed at Point Mugu, Calif. The new facilities include two surface launchers, a weight-and-balance tower, three missile-assembly buildings, a missile-guidance building, a launch-control building, and a launch-support shelter. The 8-story weight-and-balance tower is made of structural steel and corrugated asbestos siding and rests on concrete pilings.

New Naval Ordnance

Three Navy contracts have been awarded to the General Electric Ordnance Department, Pittsfield, Mass., for production of a missile fire-control director, the development and fabrication of prototypes of an acoustic torpedo, and the production of sea-water batteries to provide power for torpedoes.

The fire-control director for the Tartar missile weapon system, designated the Gun and Guided Missile Director, Mk. 73, is used with the shipboard fire-control system for acquiring and tracking hostile supersonic aircraft. The director, which will be installed aboard destroyers, employs a unique drive system that operates without power gearing to provide extreme tracking accuracy and smoothness.

The Mk. 44, Mod. 1, acoustic, antisubmarine torpedo prototype will be an advanced version of the original Mk. 44, which can be launched either from conventional deck launchers of surface vessels, dropped from aircraft, or delivered over long distances by a rocket fired from a ship with the Asroc system.

Once in the water, the Mk. 44 begins a programmed search for its target. When the target is detected by the acoustic system, the torpedo homes in for the kill. It is capable of attaining speeds and depths associated with nuclear-powered submarines.

New Sniperscope

Tomorrow's U. S. Army riflemen will be able to see farther in the dark to spot the enemy than the World War II infantrymen with a lightweight "sniperscope" infrared gun sight by Raytheon Company. Under development since 1956 for the Army Engineer Research and Development Laboratories, the new T1 sight is scheduled shortly for large-scale production.

Lightweight sniperscope in action.

The target image on the new infrared sighter is twice as big as on the World War II version—giving more positive identification. It also makes it easier to detect enemy camouflage attempts.

Instead of the former 28-pound sniperscope and back-carried battery supply load, tomorrow's rifleman will have a 13-pound unit. The power supply, one-eighth the size of its World War II counterpart, hooks on the rifleman's cartridge belt.

When a central infrared searchlight is used to spray a wide battlefield sector with infrared light, the T1-equipped rifleman simply unhooks the power supply and uses only the lightweight receiver portion—keeping him hidden from enemy infrared detectors.

The new scope can be used with virtually any individual weapon employed by combat soldiers. The World War II sniperscope was hand-tailored only for the M1 carbine.

New Submarines

The ETHAN ALLEN, first ship in a new class of fleet ballistic missile submarines, will be launched November 22nd at Groton, Conn. Designed from the keel up for firing the Polaris, the ship displaces 6,900 tons and is 410 feet long. The ETHAN ALLEN was built by the Electric Boat Division of General Dynamics Corporation.

It will displace over 1,000 more tons and be 30 feet longer than the GEORGE WASHINGTON-class ships. Now in commission and soon to be deployed with the fleet are the U.S.S. GEORGE WASHINGTON and the U.S.S. PATRICK HENRY. Three more ships in this class are due to join the fleet in 1961—the THEODORE ROOSEVELT, ROBERT E. LEE, and ABRAHAM LINCOLN.

Under construction in the ETHAN ALLEN class are the SAM HOUSTON, THOMAS A. EDISON, and JOHN MARSHALL—all of which will be launched in 1961. Construction on a fifth, unnamed ship in this class is due to start this fiscal year. Under order are 4 more ships of still another class, the LAFAYETTE class, which will be 425 feet long and displace about 7,000 tons.

Shipboard Automation

The Navy is conducting a study to reduce crew requirements of surface ships by turning over many control functions to automated machinery. Project SURIC—for surface ship integrated control—has the goal of having naval surface ships operate with fewer men, yet outperform current operating ships by simplifying and centralizing shipboard operations.

Results of the study are to be incorporated in a destroyer escort, a ship type which will continue to be a major factor in antisubmarine warfare. The Navy hopes to realize substantial cost and space savings by making use of data-processing and automation equipment.

Project SURIC is being carried out by the Office of Naval Research, Sperry Rand Corporation, and Gibbs and Cox, Inc., naval architects.

"Polaris Suit" Honored

The "Polaris suit," designed for wear by crewmen of ballistic-missile submarines, has earned an award for excellence in design. The suit is made of a blend of synthetic and natural fibers designed to require less heat from machine driers after washing—thereby cutting down on moisture expelled into the closed atmosphere of nuclear submarines. By the use of nylon stretch fabric inserts at waist and back, an entire crew can be fitted with

only three sizes. The "suit" is a one-piece shirt-and-trousers combination.

Rocket Engine Road Test

The Utah Division of Thiokol Chemical Corporation has demonstrated the feasibility of transporting live Air Force Minuteman ICBM engines for long distances over public highways. Between June 29th and July 12th, a first-stage Minuteman engine was transported in excess of 2,500 miles over highways in a 2-state area. Inspections made before, during, and at the end of the test revealed absolutely no damage to the engine.

The test was one of 18 to be completed in the near future. Distances will vary from 2,500 to 10,000 miles, and in each instance a live engine with pyrogen assembly in place will be transported.

The engine received precise visual inspection with various optical equipment before the test, at 500 miles, at 1,300 miles, and after the test was completed. Radiographic inspections made before and after the testing determined that no internal damage occurred to the engine.

Available for the inspections is the most powerful industrial radiographic linear accelerator in the Nation, recently placed in operation by Thiokol. Called the Linac, the accelerator is used to inspect Minuteman rocket-engine insulation, liner, and solid propellant through X-ray photography.

With amazing accuracy, the Linac can radiograph the propellant in first-stage Minuteman engines 10 to 12 times faster than the 1,000-curie cobalt 60 source previously utilized.

British Antitank Missile

The British War Office has ordered the Vickers Vigilant antitank missile for official infantry trials. In development for the past three years, the weapon is wire-controlled and man-portable, weighing only forty-five pounds complete.

New portable antitank missile.

The new missile needs no control panel and is launched from its carrier box and guided by hand-held sighting. It is lethal against the heaviest known armor and is instantly ready for use. The Vigilant has already been proved on airborne operations and is readily adaptable to reconnaissance and other such vehicles.

A special feature of the lightweight weapon is the high accuracy of the velocity guidance control system that is used. An infantryman can use it after only five hours of simulator training plus the firing of three or four live rounds. It has a range from close in up to a mile, and it is impossible to detect as it attacks from complete concealment.

Simplified Tracking Device

A simplified electronic tracking apparatus, which is compact, portable, and economical, has been developed for the Air Force. The device, known as SETA, is described in a research report released to science and industry through the Office of Technical Services, Business and Defense Services Administration, U. S. Department of Commerce.

Used to train pilots and operators of specialized aviation equipment, SETA is simple enough to be operated by students in laboratory classes, yet is an effective human engineering research tool. It can be used in a variety of psychological experiments such as measuring learning ability, analyzing skill processes, and determining the effects of stress.

We Believe that Peaceful co-existence is best maintained by being Too Tough to Tackle

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LACROSSE — All-weather guidance • Video target simulator

TERRIER — Beam rider guidance • Fuzing

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BOMARC — Complete automatic missile checkout and launching equipment

RASCAL — Mechanical redesign of components • Automatic test equipment

METEOR — Miniaturized pulse type seeker • Video target simulator • Homing subsystem checkout equipment

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BOEING 707

CONVAIR 880

FUEL PUMPS DESIGNED, MANUFACTURED, SERVICED BY THE TAPCO GROUP

The passenger on a jet airliner can literally see the world from a new angle. He can sit 40,000 feet above the earth and look down at ten miles of his world rolling by each minute. The view from the air is new, and it is exciting.

Two of the new jetliners, the 707 and 880, use fuel pumps designed and manufactured by the TAPCO Group. These pumps contribute materially to the performance of these outstanding airplanes. In addition, TAPCO makes many of the rotating engine components in the J57, the J75, and the J79 engines of these and other jet-powered aircraft.

Engineering and manufacturing techniques are superior at TAPCO. That is one reason we have been part of every major aircraft program since the B-17, including, today, the A3J, F8U, W2F-1, T-38, ELECTRA, F-105, KC-135, B-52, B-58 and CARAVELLE.

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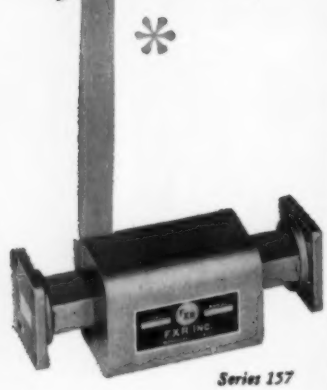

Series 157

- OPERATION: Full waveguide bandwidth
- RANGE: Waveguide 3.95 to 26.50 KMc Coax 2.0 to 4.0 KMc
- ISOLATION: 15 to 30 db depending upon range
- VSWR: Waveguide 1.15 max Coax 1.2 max
- INSERTION LOSS: 1db max

No. 1 of a series of FXR's new precision microwave components designed to meet the ever-growing needs of the microwave industry.

FXR's Ferrite Isolators are broadband, high performance waveguide and coaxial microwave components which provide maximum isolation and minimum insertion loss. In general these isolators are used in any application where it is desired to attenuate either the forward or reverse power flow without corresponding attenuation in the opposite direction. They are used to reduce the VSWR presented by a load and to isolate the oscillator for more stable operation.

Model No.	Frequency Range KMc	Minimum Isolation db	Peak Power	Price
H157A	3.95- 5.85	18	*2KW	$270.00
C157A	5.85- 8.20	20	*2KW	245.00
W157A	7.05-10	24	*2KW	245.00
X157A	8.20-12.4	30	*2KW	220.00
Y157A	12.40-18	24	**1KW	245.00
K157A	18.00-26.50	24	**1KW	270.00
K157AF†				270.00
N157A	2.00- 4.00	15	**2KW	450.00

*Load VSWR 5 **Load VSWR 2
†K157AF has the same specifications as K157A, except for the flange.

Write for Catalog Sheet No. 157

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Woodside, N. Y. / TWX: NY 43745

UNDERWATER ORDNANCE

Seabrook Hull

• *With this issue,* ORDNANCE *inaugurates a new service to is readers—regular coverage of developments, objectives, and problems of underwater ordnance. In each issue* ORDNANCE *will report on antisubmarine warfare, prosubmarine warfare, oceanography, and all matters relating to the conduct of defensive and offensive operations depending in whole or in part on utilization of the subsurface water areas of the world.*

It is the purpose of this section to report the requirements and developments of tactics and strategy, programs and projects, and applicable technologies. It is designed to inform industry, stimulate thought, and advance the state of national preparedness.

Copies of press releases, technical papers, addresses, etc., may be sent to Seabrook Hull, 912 Carry Building, Washington 5, D. C. These will contribute to the content of these pages. Queries and suggestions also will help determine which areas to emphasize from issue to issue.—THE EDITORS.

High-Speed Second Guessing.—NTDS, the Naval tactical data system developed by the Navy and industry working together, is designed to evaluate enemy underwater threats instantly and recommend countermoves in millionths of a second. The shipboard system, which has previously had all enemy ship, aircraft, and missile capabilities fed into its memory, continuously monitors a ship's radar, sonar, and communications systems; relates new information to stored data; and makes immediate judgments on best next moves.

NTDS, through its powerful single-sideband communications system can coordinate the activities of either a single ship or a whole task force. It does not, however, preempt the traditional right of a naval commander to make his own decisions. It only recommends; it does not act.

In either case, when the commander feeds his decision into NTDS, it immediately transmits the necessary orders throughout the task force. NTDS is due for shipboard installation early in 1961. Naval Electronics Laboratory, San Diego, is the coordinating office.

Two-Stage Wire-Powered Torpedo.—A 100-knot, very high voltage, electric-powered torpedo has been proposed by American Machine & Foundry Company's defense products group. The unique weapon would be driven by a 600-cycle, 12,000 r.p.m. electric motor with a power-to-weight ratio of 0.4-pound per brake horsepower. Electric power, however, would be supplied by the firing submarine.

The 21-inch torpedo would unreel up to three miles of ⅛-inch 3-element cable which would supply both power and guidance instructions through its 7-channel capacity. Upon nearing its target the warhead would break loose, powered by a small solid-propellant rocket, while the main body of the vehicle would return to the torpedo tube from which it was fired for reuse. This project, like so many others, has run up against the critical shortage of funds available in the current budget to be used for underwater ordnance research, development, test, and evaluation.

Another AMF proposal involves a small air-drop torpedo which, rather than streaking off immediately after its target, would sink slowly while zeroing in on the target with its sonar gear. With target acquisition, the weapon would divide into two parts—one remaining stationary and holding its sonar beam on the target; the other, riding the beam to an impact.

Mr. Hull is an experienced author and editor in the field of modern weapons including space and air power as well as undersea warfare.

Undersea warfare is one of the most critical and demanding areas of national defense—more important, perhaps, than outer space. Yet, the Eighty-sixth Congress

FXR's
WAVEGUIDE SWITCHES

Series 641

- OPERATION: Full waveguide bandwidth
- RANGE: 3.95 KMc to 40.00 KMc (in 7 sizes)
- CROSSTALK: 60 db min
- VSWR: 1.10 max
- Choice of manual or electrical drive
- High-power capacity

No. 2 of a series of FXR's new precision microwave components designed to meet the ever-growing needs of the microwave industry.

FXR's Waveguide Switches find applications on the test bench and in microwave systems. Operating over the full waveguide frequency ranges, these switches provide trouble-free operation with high isolation and high-power capacity. The milled aluminum waveguide rotor assures low VSWR. For long life it is mounted on ball bearings and is electrically connected to the stator through noncontacting choke sections.

MODEL NO.	FREQUENCY RANGE KMc	WAVEGUIDE TYPE RG-( )/U	*PRICE (MANUAL)
H641A	3.95- 5.85	49	$350.00
C641A	5.85- 8.20	50	300.00
W641A	7.05-10.00	51	265.00
X641A	8.20-12.40	52	225.00
Y641A	12.40-18.00	91	250.00
K641A, AF	18.00-26.50	53	275.00
U641A, AF	26.50-40.00	96	300.00

*Slightly higher for electrically driven units.

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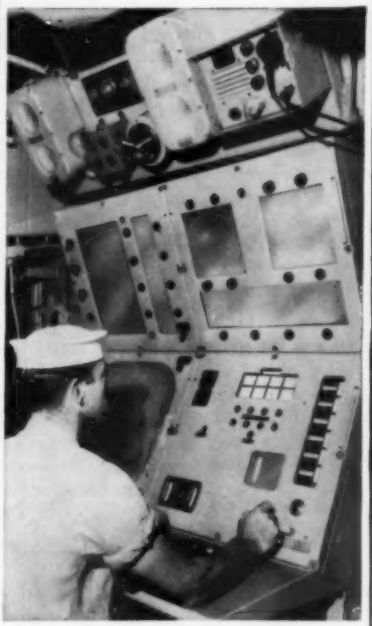
Underwater Ordnance

has again failed to ask for anywhere near enough money to support an adequate research and development effort by industry. Less than $65 million is left for this purpose after deducting costs of ship conversion, support of Government laboratories, etc. This is hardly a program designed to plug one of the nation's most serious defense gaps.

More to a Missile Than a Bird.—Below is a crewman's view of the Asroc fire-control system—the first shipboard installation of a digital computer. The

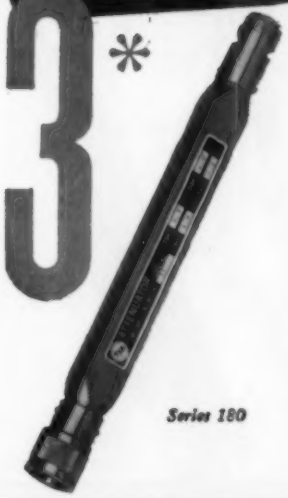


Asroc fire-control center.

system takes into account target course and speed, wind direction and speed, and attack ship course, speed, pitch, and roll. It was developed for the Navy by the Librascope Division of General Precision, Inc., Glendale, Calif., under the technical direction of the Naval Ordnance Test Station, China Lake, Calif.

Plastic Cases for Polaris.—Navy Special Projects Branch anticipates that the Polaris fleet ballistic missile, Model A-2, will achieve its anticipated 1,500-mile range in part through use of glass/plastic as a second-stage motor-case material. This case, developed jointly by the Naval Propellant Plant, Indian Head, Md., and Allegany Ballistics Laboratory, Cumberland, Md., is expected to start its full-scale flight tests within a few months. Scale model cases have been fired many times in static tests. (*Contd. on p. 392*)

FXR's BROADBAND FIXED COAXIAL ATTENUATORS



Series 180

- FREQUENCY RANGE: 0.6 KMc to 12.4 KMc
- ATTENUATION VALUES: 3, 6, 10, 20 db
- CONNECTORS: Type N — male one end, female the opposite end

No. 3 of a series of FXR's new precision microwave components designed to meet the ever-growing needs of the microwave industry.

FXR's Broadband Fixed Coaxial Attenuators are extremely useful and completely dependable in applications requiring isolation between RF components and extending power meter ranges. They may also be used for the calibration of directional couplers, in obtaining antenna characteristics and for similar applications. These attenuators have exceptional stability and are capable of withstanding appreciable overloads and peak power with no change in characteristics. They have high shock and vibration resistance and exhibit a negligible change of attenuation under humidity and temperature cycling.

Model No.	Frequency KMc	Max. VSWR	Frequency Sensitivity db	Price
N180A	.6-11.0	1.3	(− .3) (+ .5)	$42.00
N180B	1.0-11.0	1.3	(− .6) (+ .7)	42.00
N180C	1.0- 2.0 2.0-11.0	1.35 1.30	(−1.2) (+1.3)	42.00
N180D	2.0- 3.0 3.0-11.0 11.0-12.4	1.35 1.30 1.40	(−1.3) (+1.9)	42.00

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FXR's COAXIAL BROADBAND BI-DIRECTIONAL COUPLERS

4*

Model No. N616D

- OPERATION: Full two octave frequency range
- FREQUENCY RANGE: Model 616 — 0.25 KMc to 1.0 KMc
  Model 617 — 1.0 KMc to 4.0 KMc
- COUPLING: 20 ±2 db including frequency sensitivity
- DIRECTIVITY: 20 db min
- Individual calibration curves attached

*

No. 4 of a series of FXR's new precision microwave components designed to meet the ever-growing needs of the microwave industry.

FXR's Coaxial Broadband Bi-Directional Couplers are versatile components with high directivity and uniform coupling over a range of two octaves. These couplers can be employed in reflectometer setups, to monitor power and frequency or as a standard of attenuation. The built-in loads on the line can absorb 1 watt of CW power which makes the couplers ideal for the injection of large values of local oscillator power into a mixer circuit.

'The main line VSWR is less than 1.2 and the auxiliary arm VSWR is less than 1.25 including the termination.

MODEL NO.	FREQUENCY RANGE KMc	CONNECTOR TYPE	PRICE
N616D	0.250-1	N Jack	$160.00
N617D	1-4.0	UG-23C/U equivalent	150.00

Calibration curves for the incident and reflected couplers are attached to each instrument.

Write for Catalog Sheet No. 616

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Underwater Ordnance (Contd.)

Polaris Model A-3, with a 2,500-mile range, may also have a plastic first-stage motor case. Aerojet-General Corporation, Azusa, Calif., is in the early stages of a program to develop design and fabrication techniques for such a case. All-told, six companies have qualified under the SP program as suppliers of second-stage monofilament-wound motor cases.

Sound Lice for Sea Search.—Miniature sonar transponders equipped with magnets are now being used to locate valuable items of oceanographic and undersea warfare research that might otherwise be lost. Developed and supplied by Maico Electronics, Inc., Minneapolis, Minn., these units are attached magnetically to the item of interest. If, during underwater operations, the item is lost (due, say, to a cable breakage), it can easily be located through the characteristic signal sent out by the transponder. These miniature noisemakers can also be fired in a hedgehog pattern at a suspected submarine contact. Once stuck to the submarine's hull, the transponder's signal makes it an easy target.

Planer Threatens Hydrofoils, Hovercraft.—The amphibious assault vehicle capable of 40 knots or better being developed by Ingersoll-Kalamazoo Division, Borg-Warner Corporation, Kalamazoo, Mich., may have direct application as a high-speed coastal ASW search-and-kill craft. The gas-turbine-powered assault craft is lightly armored and sports four retractible wheels. Borg-Warner Corporation feels that, without the armor and the wheels, greater speed could be realized in the planing attitude, thus making it a direct competitor with the hydrofoil and ground-cushion-effect vehicles for the out-to-200-miles coastal search mission.

From Davy Jones' Locker

Problem in Materials: As underwater ordnance must operate at greater and greater depths, materials problems become increasingly serious. Even as solid rocket motor cases hit the brittle failure barrier (at a minimum yield strength of about 220,000 p.s.i.) under high tensile stress ("notch sensitivity"), so will deep-diving submarines encounter a similar problem under the combined compressive stress of static pressure and dynamic load due to underwater explosions. This poses a serious threat to steel as a hull material. Inclination now is toward aluminum, titanium, etc. Glass and plastic also are being considered. All investigations are in the early stages.

Problem in Design: Look for increasing application of aircraft and missile space- and weight-saving techniques to submarines and underwater ordnance. The sheer weight of hull and structure of craft designed to operate at great depths (5,000-to-10,000 yards) will be such that severe limitations will be imposed on submarineborne equipment and ordnance. Remember: Even though the modern nuclear submarine is primarily an underwater boat, it still has to be able to float when surfaced!

Problem in Noise: One of the severest problems today is that of mechanically transmitted sound—noise of blowers, generators, circulation systems, turbines, etc., transmitted through the structure to the surrounding water. This problem is so severe that the cruising nuclear submarine makes no pretense of really trying to be quiet, but rather relies on noisemakers to change its sound signature in order to confuse the enemy.

Vibration (or noise) mounts for submarineborne equipment must have a natural frequency of eight cycles per second, or less, in order to be below critical ranges. These mounts also should be able to protect submarineborne equipment under conditions of severe shock.

One answer may be a new unique steel cable shock and vibration isolator, developed by Kerley Engineering, Inc., College Park, Md. Steel cable noise isolation systems with a natural frequency of five cycles or less have been designed that also provide good protection in shock.

Problem in Identification: "I know it's there, and I know about where 'there' is. But, what is it?" It is probably debatable if this is *the* most serious ASW problem, but everyone agrees it's one of the most serious. The danger is that in time of combat a great deal of very costly ordnance will be fired at false contacts—with the threat, even, of a submarine exhausting all its weapons in this manner.

This is one area in which the Navy is wide open for any new idea that can be backed with evidence. It does not necessarily have to depend on sound. (In this respect, one of the great current mysteries is how, under certain undefined conditions, surface radar can precisely track a submerged maneuvering submarine—as has occurred on a number of occasions with ASW surface units.)

UWO News Items

U. S. Coast & Geodetic Survey has been reorganized to provide for greater effectiveness in scientific research and oceanography. Established are two new offices: Office of Research & Development, and Office of Oceanography. . .

Navy launched its twenty-first atomic submarine on October 8th as the attack submarine SCAMP slid down the Mare Island Naval Shipyard ways. . .

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MODEL NO.	FREQUENCY RANGE KMc	WAVEGUIDE TYPE RG-( )/U	PRICE
W176A	7.05-10.0	51	$185.00
X176A	8.2-12.4	52	165.00

Write for Catalog Sheet No. 176

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Woodside, N. Y. / TWX: NY 43745

Underwater Ordnance

Navy has contracted for three more Polaris submarines—two to be built by Electric Boat Division, General Dynamics Corporation, Groton, Conn., and one by Newport News Shipbuilding and Drydock Company, Newport News, Va. This brings to fourteen the number of Polaris submarines in commission, under construction, or on order. . .

Northrop Corporation has received $28 million in contracts for Polaris work—including automatic checkout systems, gyroscopes, periscopes, and radiometric sextants. . .

First Polaris fire-control trainer to train Polaris submarine crews in simulated missile launchings has been delivered by General Electric's Specialty Control Department, Waynesboro, Va. Buyer is Naval Training Devices Center, Port Washington, N. Y. . .

Avco Corporation renames its Crosley Division—now calling it Avco Electronics and Ordnance Division, as more descriptive of the unit's activities, which will include among other things marine electronics equipment. . .

Contract to measure bearing noise has been awarded by Navy to SKF Industries, Philadelphia, Pa.—part of submarine noise-reduction program. . .

Underwater Retriever.—The model of a monster of the deep shown below about to grasp a spent torpedo is one of the latest underwater ordnance aids developed for the Navy. Called Solaris and

Solaris retrieves spent torpedo.

developed by Vitro Laboratories, Silver Spring, Md., it has a built-in TV camera and four 500-watt lights for seeing; it can maneuver and search at depths down to 2,000 feet; and can retrieve objects weighing up to 7,500 pounds in water. In addition, it also can plant explosives and other objects on the ocean floor.

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MODEL NO.	FREQUENCY RANGE KMc	WAVEGUIDE TYPE RG-( )/U	PRICE
S175A	2.60-3.95	48	$365.00
H175A	3.95-5.85	49	240.00
C175A	5.85-8.20	50	135.00
W175A	7.05-10.00	51	115.00
X175A	8.20-12.40	52	95.00
Y175A	12.40-18.00	91	115.00
K175A, AF	18.00-26.50	53	240.00
U175A, AF	26.50-40.00	96	250.00
Q175A	33.00-50.00	97	475.00
M175A	50.00-75.00	98	425.00
E175A	60.00-90.00	99	675.00

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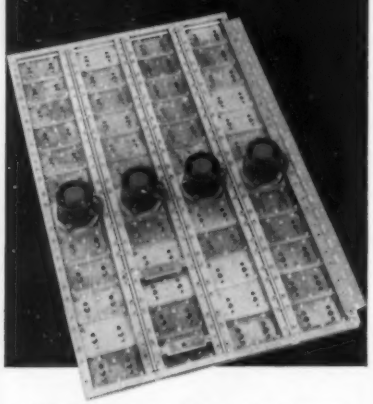
Environmental conditioning *for detection systems*



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Los Angeles 45, California

MATERIALS PROGRESS

George S. Brady

Metallurgical Research Results.—Research work done on plutonium during the past fifteen years, and now being extensively "unclassified," may well serve to alter our whole basic approach to the alloying of metals.

Plutonium metal does not occur naturally in any usable quantities, and is made at great cost in nuclear reactors. It is a hazardous metal to work with, and it may never be employed in any commercial foundry. Nevertheless, the deep study that has been made of the atomic interrelationships of plutonium alloying opens the way for a better understanding of the reasons behind the changes in characteristics of metal mixtures, and thus can short-cut the work of alloy development.

Until quite recently the alloying of metals was purely empirical, by the "trial-and-error" method of mixing metals, and foundrymen not infrequently boasted of the great number of mixtures they melted and tested before arriving at the "right" alloy for a given purpose. In more recent years, metallurgists have been able to deduce enough general principles to eliminate much of the trial-and-error testing, but this, while scientific, has been largely limited to the observation of outward effects, such as chemical interactions, formation of carbides, and growth of crystals.

But, for the alloying of plutonium for the very accurate requirements of nuclear applications, the atomic scientists had to dig deeper into basic causes, and the unusual number of allotropic forms of this metal—six—required the researchers to study in detail the reasons for these form changes. Now, with a better understanding of the physical alterations in metal atoms in contact with other atoms, the day may not be far distant when the theoretical physicist can compute in advance much more limited ranges of testing in which the "right" alloy for a given set of conditions ought to be found.

In alloying, the introduction of a foreign atom into a metal may modify the relative stability of the allotropic phase by changing the number of electrons in the valence ring of the base-metal atom, thus changing the bonding and the lattice parameter (shape of crystal). The atomic size also has an effect in enabling an alloying element of smaller size to position itself within the atomic boundaries of larger atoms.

In the study of plutonium it was found possible to select in advance the alloying elements according to their progressive degree of solubility by plotting the electronegativity values as ordinates and the atomic radii as abscissas on a chart. An ellipse with the vertical axis equal to a given electronegativity tolerance, and the longitudinal axis with an allowable percentage tolerance for difference in atomic radii, when centered on the point for the base metal of the alloy contained within it those elements which were soluble within the prescribed tolerance.

However, in departing from binary compounds, the subject becomes more complicated, since, when there are more than two metals in the alloy, intermetallic compounds may be formed with covalent bonding or other more complex bondings. As most commercial alloys have more than two constituents, much research has yet to be done, but the work so far accomplished has pioneered the way.

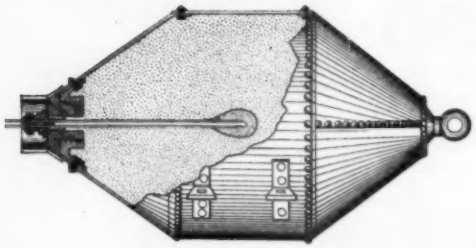
Some elements, like silicon, have stable valence, and the effect on an alloy is likely to be purely chemical. Others, such as lithium and boron, are hypoelectronic, with fewer electrons available than are acceptable for orbital bonding, and thus accept electrons into these orbitals. But the boron atom is about 25 per cent smaller than the atoms of iron, nickel, cobalt, or chromium, and may serve to increase strength and hardness as an interstitial element.

The hyperelectronic elements, like nitrogen and oxygen, have more valence electrons than are needed by the bond orbitals, and may give up an electron. Still another class of element, like nickel or cobalt, with "buffer atoms," can accept or donate electrons without changing valence.

Many data already have been "unclassified," but much study and follow-up work undoubtedly will be necessary to make them more generally useful. It seems certain that the old idea that alloys are merely mechanical and chemical

Colonel Brady is a consulting engineer, author, and editor, Washington, D. C. He is a well-known authority in the field of materials, and his "Materials Handbook" is a recognized source of information on the subject.

No. 3 in the series of A.O.A. monographs on Civil War armament



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Materials Progress (Contd.)

mixtures of the metals has been shattered. It is evident that shifting of the electrons occurs in the mixtures and that the electron levels of the metallic atoms not only depend on the environment of the atom in the alloy but may also vary with the temperature of formation.

Thus, the same metal in an alloy, for example copper, which has a hyperelectronic atom, may not have the same atomic structure as in the original metal alone and may be different in different alloys.

All this does not mean that the foundryman of the future will have to be an atomic scientist, any more than a surveyor needs to be a mathematician to use a table of logarithms. Once the scientific principles are deduced and tabulated, they can be used by the "layman."

High-Dielectric Ceramics.—A new process developed by *Gulton Industries, Inc.*, Metuchen, N. J., for making ceramic electronic parts, reduces voids and gives higher density, thus producing parts with higher dielectric constant, lower dielectric loss, and greater consistency of electromechanical properties.

The ceramics, designated as Glennite HT-8, are made with ultrapure materials of consistently uniform grain size. Very high pressure from three axial directions is applied during the firing. Barium titanate parts made by the process show a specific dielectric constant of 4,300 compared with 1,500 for conventional barium titanate ceramics.

Superstrong Graphite.—*General Electric Company* has succeeded in producing large thin-walled parts, such as nose-cone shields, of its new pyrolitic graphite and has released additional technical data on this material. The graphite has a high density, and sheets as thin as 0.001-inch are impervious to liquids and gases. The flexural strength is around 25,000 pounds per square inch, compared with less than 8,000 for the best conventional graphite.

The material is made by placing hot graphite in a stream of methane or other hydrogen gas. The carbon of the gas is deposited on the surface of the ordinary graphite. The new material grows as carbon crystals with their flat planes parallel to the original surface and builds up into a homogeneous structure of close-packed columns of crystals joined with strong bonds along the flat planes, but with only weak bonds between layers.

The pyrolitic graphite has a silvery-gray color, is hard and dense. At a temperature of 5,000 degrees Fahrenheit it has a tensile strength of about 40,000 pounds per square inch, 40 times higher than tungsten metal at that temperature. Above 3,000 degrees it is more resistant to oxidation than ordinary graphite, and above that temperature it is also claimed to have the highest strength-weight factor of any presently known material.

Weldable Stainless Steels.—In a search for improved weldability in stainless steels, *Westinghouse Electric Corporation* has been making extensive studies of the effects of alloying elements in the steels, basing the work on the standard 20-per cent-nickel, 16-chromium type. It has been found that carbon, copper, aluminum, tantalum, columbium, titanium, zirconium, and boron all cause cracking. Even the small quantities of titanium or columbium used for stabilizing cause severe cracking.

Additions of manganese up to seven per cent decrease the tendency of the steel to crack. Molybdenum and tungsten also decrease cracking. Vanadium is neutral as regards cracking tendency and can be used as a strengthener without bad effects. Silicon and carbon should be kept as low as possible in the nickel-chromium steels to avoid welding cracks. Pilot-plant quantities of some of the noncracking "superweld" steels have been made for welding rods under the name of Kromarc.

Strong High-Temperature Alloys.—*Union Carbide Metals Company*, Niagara Falls, N. Y., has been studying vanadium-columbium alloys for high-temperature use. It has found that vanadium alloy with 20 to 50 per cent of columbium retains a tensile strength in excess of 100,000 pounds per square inch at 700 degrees centigrade and 70,000 pounds at 1,000 degrees. At 1,200 degrees centigrade (2,192 degrees Fahrenheit) the tensile strength is 40,000 pounds per square inch, and oxidation resistance is higher than for pure vanadium.

However, because of the cost and relative scarcity of these two metals, the alloys will probably find application only to fill special construction needs. The study has been made in conjunction with Air Force research on refractory metals. The Air Force is searching for alloys with high strength and oxidation resistance above 2,000 degrees Fahrenheit.

Protecting Columbium.—For protecting columbium metal from oxidation at temperatures to 2,000 degrees Fahrenheit, the *Naval Research Laboratory* has found that when the columbium part is dipped in molten zinc and then heated in the air to about 1,600 degrees Fahrenheit the zinc reacts together with the columbium to form a thin coating of zinc-columbium oxide on the surface which protects from further oxidation.

Uranium Steels.—Prior to World War II, tool-steel manufacturers found that small additions of uranium added hardness and some other desirable properties

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Materials Progress (Contd.)

to steels, but the metal became unavailable for such use. But now that nonradioactive uranium has come into the market as a by-product of U-238 extraction, renewed attention is being given to its use in fine steels. *Atlas Steel, Ltd.*, Welland, Ont., is adding 0.05 to 0.20 per cent uranium to some experimental steels. It forms fine stable carbides and aids in hardening and tempering. It also is a deoxidizer and forms nitrides.

Close-Tolerance Castings.—The Shaw process is being used at *Watertown Arsenal*, Watertown, Mass., for the production of high-strength, close-tolerance parts for the M85 machine gun, with important savings in finishing costs. The process also seems adaptable for larger parts such as the 900-pound breech ring for the 105-mm. tank rifle.

In the Shaw process, developed in England, a slurry composed of refractory ceramic powders, an ethyl silicate base medium, and a gelling agent, is poured over the pattern. When the mold is stripped from the pattern it is ignited to burn out the volatiles, leaving a "microcrazed" surface structure. These micro fissures in the mold are small enough to prevent molten metal from entering, but are large enough to allow gases to escape and to permit expansion of the ceramic particles when heated by the molten metal.

The result is a dense casting without porosity, cracks, surface inclusions, or other usual defects. Castings are sound, with a fine, uniform grain structure and smooth surface. The method permits casting of adjacent light and heavy sections not generally possible otherwise.

One part of the M85 gun thus produced is the flash suppressor, a tapered piece four inches long and two inches diameter with five splines, too large for investment casting. It is of SAE 4340 steel. Another M85 part, the 18-inch gun-barrel support, was previously machined from a solid forging of SAE 4340 steel. The only machining in the cast part is the removal of the parting line flash.

Weight Saving in Cars.—Savings in weight and in maintenance costs were prime objectives in the design of the 270 new cars now being built by the *Budd Company* for the Philadelphia subway system. Subway cars are subject to continuously severe operating service conditions.

The 55-foot, 56-passenger cars weigh 52,000 pounds, a saving of 6,000 pounds from previous cars. Underframes are of NES 65 low-alloy, high-tensile steel. Frame construction is of Type 201 and 202 low-nickel stainless steel. Interior trim is of nonnickel Type 430 chromium stainless steel. (*Continued on p. 400*)

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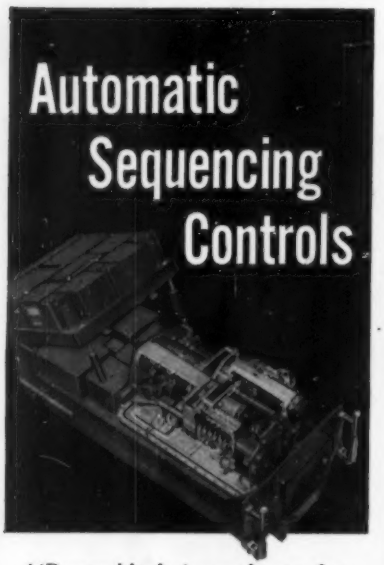

AiResearch's design and manufacturing capability covers many types of automatic sequencing controls such as those for missile ground checkout, controlling drone and missile flight profiles, and automatic elevation and leveling of radar antennas and missiles.

Above is an AiResearch sequence controller for cabin temperature of a jet airliner. It assimilates 25 sensor element inputs and supplies command signals to 18 amplifier channels. Consisting of servo-operated potentiometer cards, cam switch programmer and other electromechanical components, it is another example of AiResearch's over-all ability to design and produce intricate and complicated servo systems.

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THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

Materials Progress (Contd.)

The seat frames are of aluminum, and the seat covers are vinyl-coated duck. The flooring is aluminum-faced plywood, and the paneling is melamine plastic laminated to plywood. The front-end interior panels are glass-polyester molded in one piece. The estimated power saving is about 12 per cent, and maintenance costs are expected to be reduced more than $400 annually per car.

High-Pressure Lubricants.—*General Electric Research Laboratory,* Schenectady, N. Y., in a search for better solid-film lubricants for very heavy loads, finds that the addition of about ten per cent of various organic sulphides of metals to molybdenum sulphide will greatly increase the load-carrying capacity. Sulphides of antimony, silver, mercury, lead, and titanium have been used. In operation, the additive decomposes to produce a lubricating layer of iron sulphide on the bearing surface.

Giant Aluminum Reflector.—About 1,000 tons of aluminum were used in the 600-foot-diameter saucer-shaped reflector dish of the new Navy radio-telescope at Sugar Grove, W. Va. The dish consists of two layers connected by tubular trusses. The top layer of the dish is a thin expanded mesh. The bottom is built up of 108 rectangular panels each made of 2 triangles, all welded together.

Aluminum alloy 5456 is used for the sheet and plate, and the extruded tubes are of alloys 5456 and 6062. The dish can turn a full 360 degrees and tilt from zero to 90 degrees. *North American Aviation, Inc.,* and *Reynolds Metals Company* were the constructors.

Titanium Corrosion.—Work done at the Argonne National Laboratory by *Union Carbide Metals Company* and the *Columbia Southern Chemicals Corporation* on the improvement of the corrosion resistance of titanium indicates that as little as 0.2 per cent of palladium added to titanium makes the metal highly corrosion resistant. In a boiling 5 per cent solution of sulphuric acid, the alloy was unaffected in a 170-day test. In a boiling stream of 73 per cent calcium chloride the alloy was unaffected while the unalloyed titanium was badly pitted.

Aluminum Trucks.—Light weight is featured in the new trailer carriers for liquid oxygen and nitrogen of the National Cylinder Gas Division, *Chemetron Corporation.* About 10,000 pounds of aluminum plate and extrusions are used in each trailer, giving a weight saving of 9,000 pounds and an increased carrying capacity of 40,000 cubic feet. The high-strength weldable aluminum alloy 5083 was used in the tank plate. The two concentric tanks are separated by 6 inches of expanded silica insulation.

AiResearch integrated environmental conditioning of aircraft fire control systems achieves high effectiveness while reducing space and weight requirements.

Representative of AiResearch progress is this air-to-air environmental conditioning package which uses the integral heat exchanger and cold plate cooling unit as the base and mounting frame of the pressurized enclosure for the fire control system transmitter. Net weight of this unit is 9.5 lb. with a heat rejection of 425 watts.

This example illustrates the important economies which can be achieved when AiResearch is contacted early in the design stage of electronic systems.

Environmental conditioning equipment has been produced for the following electronic systems:

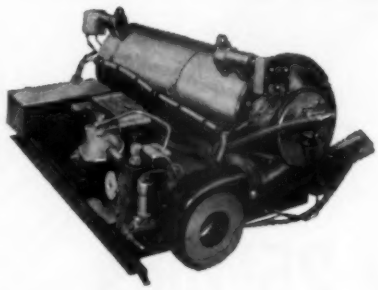
Detection · Communication · Control · Ground Support · Guidance

Write for literature today.

THE GARRETT CORPORATION

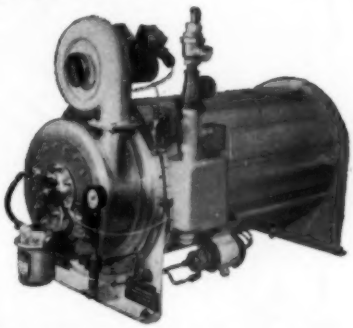
AiResearch Manufacturing Division

Los Angeles 45, California



90,000 Btu/hr Janitrol liquid heater

for support vehicle comfort and cargo heating, windshield defrosting. Ideal for use on fire trucks, movers, weapons loaders, personnel carriers, in temperatures to −65°F.



500,000 Btu/hr Janitrol liquid heater

for structures, large vehicles, and for heating decontaminants and cleaning fluids on mobile ice removal units.

1,000,000 Btu/hr Janitrol liquid heater

for heating chemicals during storage and transfer, vaporizing liquids, and in a wide variety of support vehicles and buildings. Approximately 18″ in diameter, 47″ high, weight: 270 lbs.

liquid heater packages for reliable ground support

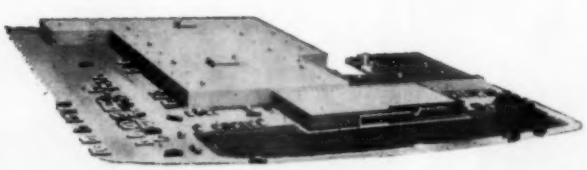
Missile and aircraft support equipment builders use Janitrol liquid heater packages—for comfort and cargo heating, structures, special vehicles, or wherever the convenience of liquid heat can be utilized—because they're built for and have been proved in scores of military applications.

They meet appropriate MIL specifications, are fully qualified, and are supplied in outputs up to one million Btu/hour. They provide any desired amount of heat up to rated output and automatically maintain constant temperatures.

As an example of acceptance, most Air Force crash-fire vehicles are equipped with one or more of these heaters, for engine, chemicals, cargo and crew space heating. Multi-fuel operation is standard, and they perform reliably in multiples for heat requirements which exceed the output of a single unit.

Write for detailed specifications proposals to the Liquid Heater Department, Janitrol Aircraft, a division of Midland-Ross Corporation, Columbus 4, Ohio.

pneumatic controls • duct couplings and supports • heat exchangers • combustion equipment for aircraft, missiles, ground support



JANITROL

Write for "Janitrol Resources," brochure on Janitrol capabilities.

Rough terrain crane lifts 20 ...weighs only 25 tons

Versatile 20-ton mobile crane equipped with a 30-ft. strut boom. (Not shown, but available as optional equipment are a 30-ft. goose-neck boom and three 20-ft. insert sections.) Unit can be used for normal crane work and also as a light bulldozer, clamshell or drag-line. Designed under the auspices of the U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va.

This mark tells you a product is made of modern, dependable Steel.

Built light and strong with USS "T-1" and TRI-TEN Steels.

Designed for Army Engineers' Airborne operations, for transportation by landing craft or overseas railroad, this crane had to be built light. Total weight of the crane was held to 25 tons by utilizing the *extra* high yield strength of USS "T-1" Constructional Alloy Steel and the high strength of USS TRI-TEN Steel.

Three and a half tons of USS "T-1" Steel, with a minimum yield strength of 100,000 psi, were used in the entire frame of the carrier and in portions of the wheels, wheel spindles, dozer, dozer arms and steering linkage. These parts were designed to a working stress of 50,000 psi and helped keep the carrier portion of the crane's weight down to 30,000 pounds; the remaining 20,000 pounds of the crane's total weight are contained in the craning machinery, cab and boom.

LeTourneau-Westinghouse engineers, who designed the carrier, say that it would have been impossible to meet the military weight requirements without this steel. They were pleased with "T-1" Steel's welding characteristics and its reliability throughout the test program.

USS TRI-TEN High Strength Steel, with a minimum yield point of 50,000 psi, was used for the chords of the boom for maximum strength, weldability and weight reduction. The rotating crane unit was designed and built by the American Hoist & Derrick Company under a subcontract from LeTourneau-Westinghouse Company.

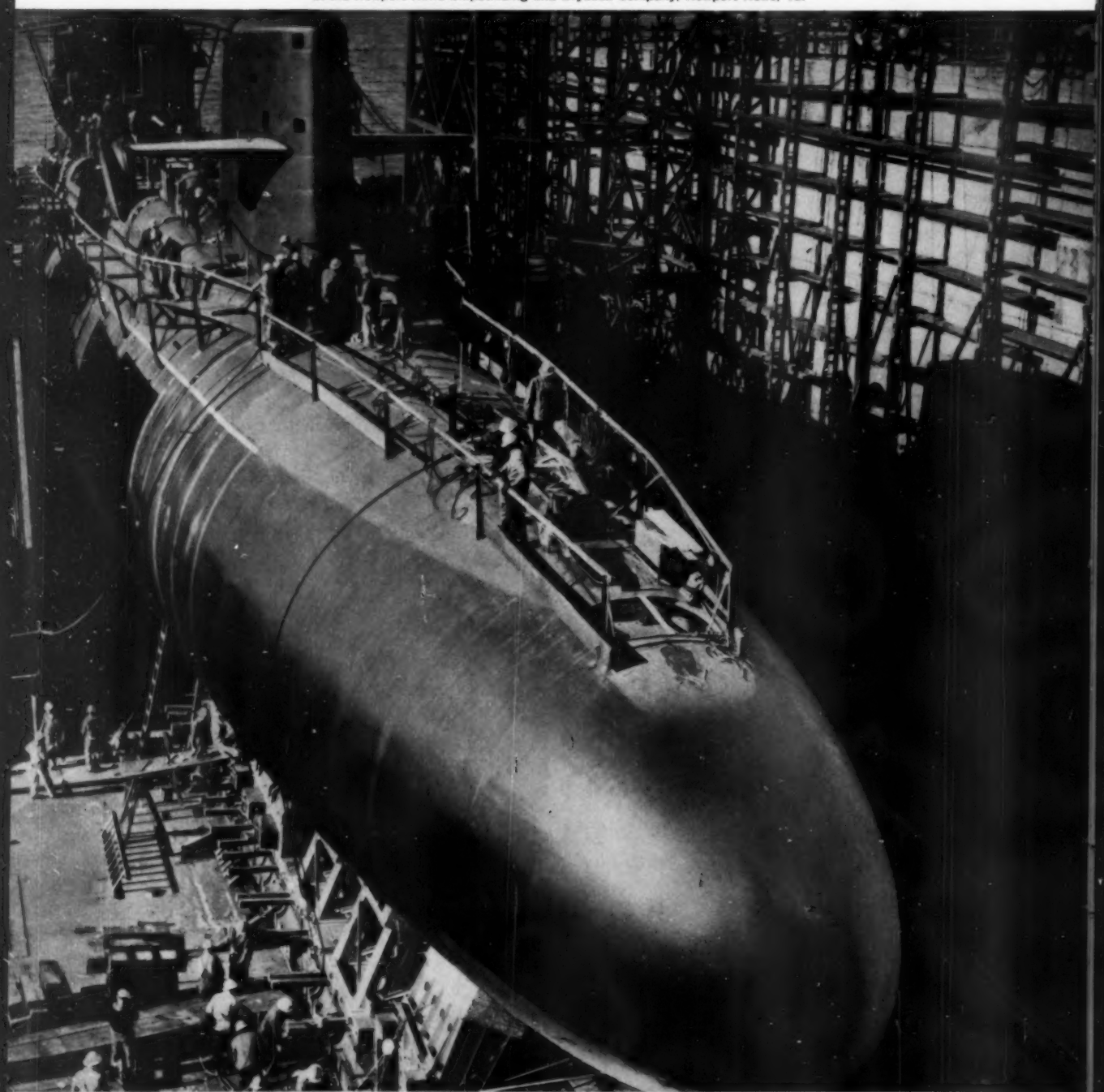
United States Steel makes two other high strength steels with minimum yield points of 50,000 psi—USS COR-TEN Brand, noted for strength with superior resistance to atmospheric corrosion, and USS MAN-TEN Brand for strength with abrasion resistance. For more information on any of these special steels, write United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS, "T-1", COR-TEN, MAN-TEN and TRI-TEN are registered trademarks

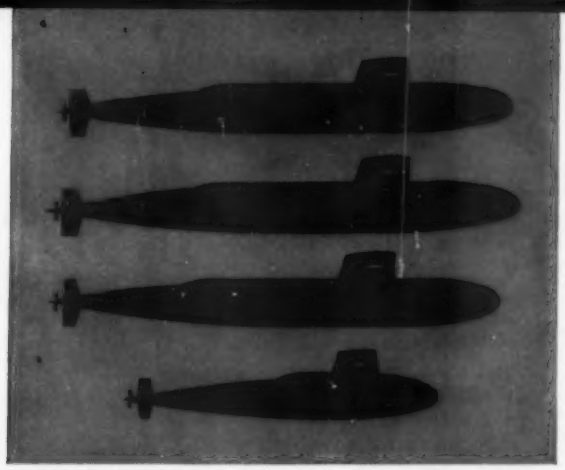
United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
National Tube—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company
United States Steel

No more waiting for the

Workmen put the finishing touches on the hull of the nuclear-powered submarine ROBERT E. LEE at the Newport News Shipbuilding and Drydock Company, Newport News, Va.



Robert E. Lee



Shown above are silhouettes of ROBERT E. LEE, SAM HOUSTON, JOHN MARSHALL and SHARK (top to bottom), built by Newport News Shipbuilding and Drydock Company.

The Navy's wait for one of its newest atomic submarines is over. Here, just before her launching, is the SSBN ROBERT E. LEE. Built by the Newport News Shipbuilding and Drydock Company, she was designed to fire a Polaris missile from both submerged and surfaced positions. Her hull, like those of the SHARK, SAM HOUSTON and JOHN MARSHALL, also under construction at Newport News, utilizes USS HY-80 (MIL-S-16216) alloy plate steel.

The revolutionary deep submergence performance of the ALBACORE-type hydrodynamic hulls on the Navy's newer nuclear-powered submarines is possible only because they're built of HY-80 Steel. Co-developed by the Navy and U. S. Steel, this special alloy steel plate serves a dual purpose: as a high yield strength constructional steel, it assures the integrity of the submarine pressure hull at deep submergence pressures, and its superior toughness, proved by low temperature notched impact tests, provides added protection against depth charge attack. Here is the rare combination of high yield strength and exceptional shock resistance.

Here welders work on submarine interbottom, welding USS HY-80 alloy plates.

For many years, U. S. Steel has been a leader in developing special steels for military applications. Besides HY-80 Steel, some others are:

HY-125 (MIL-S-19315), a U. S. Navy/U. S. Steel armor plate development designed to provide an optimum combination of protection against small arms attack and of shock resistance in a high yield strength constructional alloy steel. Ideal for such lightweight designs as hulls of Navy landing vehicles, it can be fabricated in a wide range of structural applications where a high strength material is required.

STS (MIL-S-20154) combines strength and toughness to withstand oblique attack by large caliber naval warfare projectiles. This rolled steel armor plate is widely used as a constructional steel in aircraft carriers.

Tank Armor (MIL-A-12560) is hard, tough, and sound for optimum protection against armor-piercing projectiles and blast. U. S. Army Ordnance Corps specifies it in many combat and tactical vehicles. Its exceptional strength in light gages improves vehicle performance.

If you need ballistic protection, lightweight design, ease of fabrication and material economy, U. S. Steel can supply your answer. Available, too, is new literature on HY-80 Steel. Write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

This mark tells you a product is made of modern, dependable Steel.

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company
United States Steel

USS

SPACE ARMAMENT

Communications Satellite

The U. S. Army's Courier satellite launched from Cape Canaveral in October is a communications experiment. The 500-pound, 51-inch device can simultaneously receive and send 340,000 words—approximately 3 novels—in a 5-minute period.

Courier was transferred to the U. S. Army in September 1960 by the Defense Department's Advanced Research Projects Agency and was developed under the technical direction of the Army Signal Corps at the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J. It was successfully fired into orbit by a U. S. Air Force Thor-Able-Star missile.

Courier can send approximately 68,000 words a minute and receive and store the same amount simultaneously. It can communicate with two stations, one in Puerto Rico and the other at Fort Monmouth. Commands to the satellite are coded to avoid unauthorized use of its communications capabilities during the experiments by the Army Signal Corps.

Courier is the forerunner of a series of communications satellites that could revolutionize worldwide communications. As an experimental research and development vehicle, it uses frequencies in the ultra-high range, never before used for satellite communications. The use of this band has several advantages. It is a relatively unused part of the radio spectrum and thus free from interference by other man-made signals. It is also not disturbed by natural causes such as magnetic storms which can blanket the lower frequencies.

Sun's Spectrum Photographed

Photographs of the ultraviolet spectrum of the sun obtained recently by a U. S. Naval Research Laboratory Aerobee rocket fired at the White Sands Missile Range, N. Mex., are expected to give scientists new data on the sun and its atmosphere.

The NRL experiment, investigating solar radiation between the 2,000- and 3,000-Angstrom wavelength of the spectrum, represents the first time that this portion of the spectrum has been examined successfully in such detail. Photographs of the spectrum of this powerful ultraviolet radiation make possible a tremendous advance toward understanding the relationship between solar activity and its influence on the earth.

Launched from its pad in the New Mexico desert, the space vehicle soared over ninety miles into the atmosphere. As the Aerobee traveled upward, the rocket nose cone's pointing control system, developed by Aircraft Armament, Inc., of Baltimore, Md., kept the sun's radiation directed into the spectroscope, an optical instrument for separating the radiation into its various wave-length components. At different times during the flight, the ultraviolet-sensitive instrument took photographs of the sun's spectrum at various exposure lengths.

Echo's Orbit Analyzed

Solar radiation pressure and atmospheric drag have had significant effects on the orbit of the Echo I satellite, according to scientists at NASA's Goddard Space Flight Center. Pressure due to sunlight decreased Echo's perigee from 932 miles on August 12th to 864 miles on September 11th. Atmospheric drag decreases the orbital period about one second a week.

Apart from the communications experiments associated with Project Echo, the 100-foot inflatable sphere is a sensitive instrument for detecting characteristics of the space environment. This is due to its exceptionally high area-to-weight ratio—50 square feet per pound, or an average of 1,000 times greater than previously launched satellites.

The total force which sunlight exerts on the sphere is only 1/50 of an ounce. Even this slight pressure pushes the Echo I perigee downward 3.5 miles a day, according to Dr. Robert Jastrow and Robert Bryant of Goddard's Theoretical Division after an analysis of tracking data. This pressure has changed the shape of the Echo orbit from nearly a circle at the start to an ellipse today. Solar radiation pressure will in the coming months return the orbit to a circle, and the process will be repeated periodically.

Lunar Road Map

The Interior Department's Geological Survey recently completed a terrain study of the moon for the Army Chief of Engineers to provide lunar surface information for selecting landing sites and as an aid in designing telemetering instruments and a lunar surface vehicle.

This is the first photogeologic study known to have been made of the moon. It has been published by the Corps of Engineers under the title "Engineer Special Study of the Surface of the Moon." The study consists of three diagrams, all of which show the visible face of the moon at a diameter of thirty-six inches, and an accompanying text.

One diagram shows the physiographic regions of the moon. Each of the regions is named and outlined, and many distinctive physical features are identified.

The second diagram is a generalized photogeologic map of the moon. The relative ages of the various craters and seas are shown. Craters having a central peak are distinguished from those lacking one. Structural features such as fracture patterns, faults, anticlines, and monoclines are included. An accompanying scale is graduated to compensate for the curvature of the moon, so that distances may be measured in any part, and sizes of features determined.

A third diagram depicts the prominent lunar rays. Interpreted as splashes of crushed rock derived from the impact of large fragments thrown out at times of meteoric impact, some of these rays extend hundreds of miles from their craters.

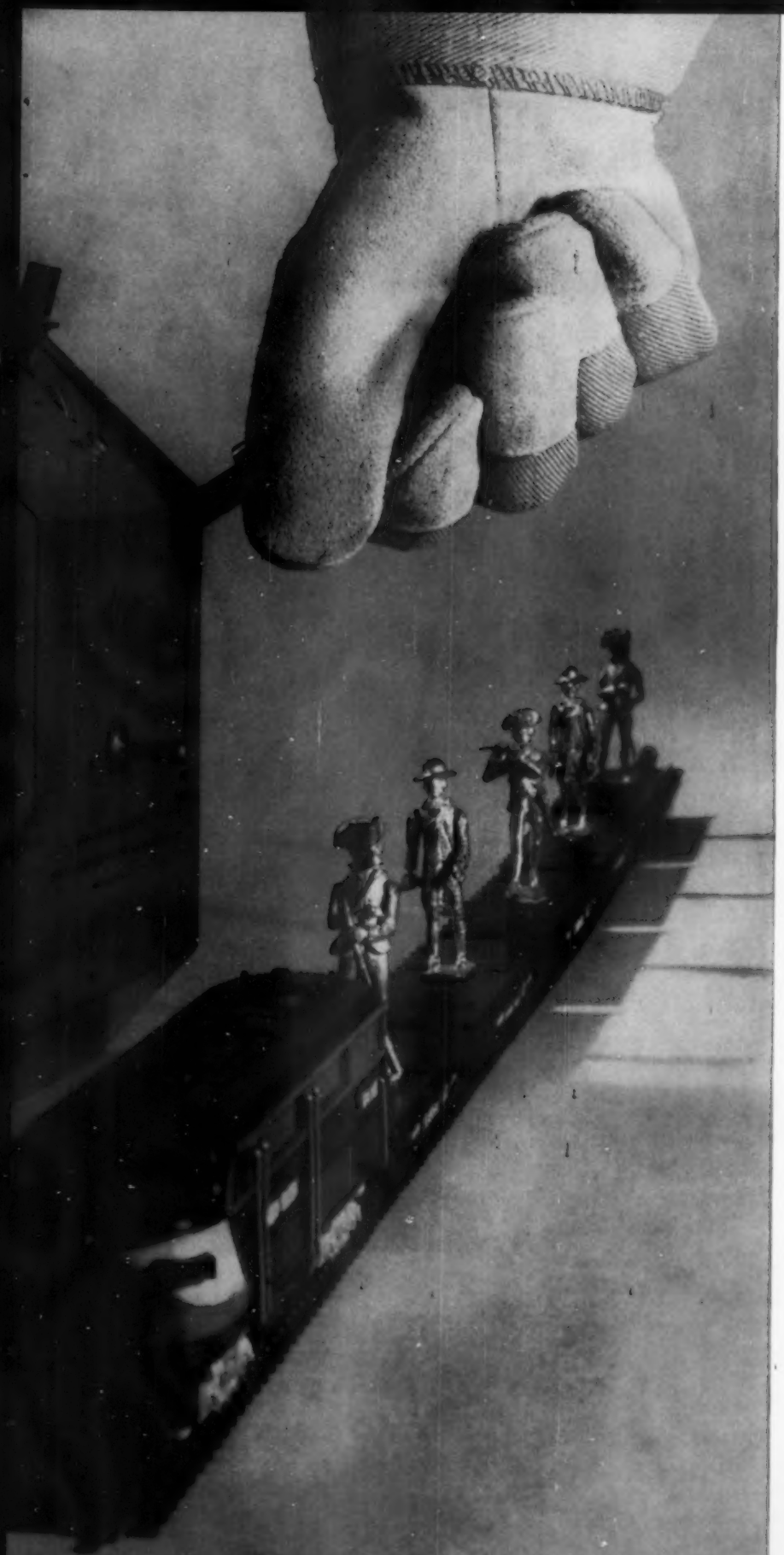
New Earth Measurement

Scientists of the U. S. Coast and Geodetic Survey have achieved a spectacular degree of accuracy in earth measurement in support of the Air Force missile program. With unprecedented precision the Coast Survey succeeded in tying a network of 9 missile tracking ballistic cameras, spread over an area of 4,000 square miles, with the launching site at Cape Canaveral, Fla., to pinpoint tracking of space missiles and flares against a background of stars.

The camera sites were calculated to within an average probable error of about 0.2 foot with respect to a fixed point at Cape Canaveral, achieving an accuracy of better than one to 1,000,000, or 1/16 of an inch in one mile—about the width of a toothpick.

This is the greatest accuracy ever accomplished in any geodetic survey of any extent and is ten times greater than the rigid standards prescribed for first-order triangulation of the Survey.

The nine ballistic cameras included in the network were located from 40 to 50 miles distant from instrumentation at Cape Canaveral, Fla. The survey involved 65 triangulation stations and 200 lines in a solid area of quadrilaterals. Of these 200 lines, 43 were actually measured with the Geodimeter, using its favorable characteristics of precision in measuring distances by the speed of light.



He's got Minutemen "working on the railroad"

Hard basing is one way to protect America's force of retaliatory ICBM's. The problem was to find an alternate means of accomplishing the same mission. The Air Force solution was a new ICBM mobility concept—railroad car-mounted Minutemen, utilizing the nation's vast track mileage for numerical and geographical dispersion, creating a difficult target for enemy attack.

To put the Minuteman, its support systems and associated equipment on rails was a completely new problem in missile handling. The first requirement assigned by Boeing to American Machine & Foundry Company and ACF Industries, Inc., was a feasibility study of the existing limitations of roadbeds, rails, railroad operations and right-of-way. Unique tactical cars are being designed within these limitations to carry the Minuteman—cars that can handle the missile and its operating equipment, safely isolated from roadbed shock and ready for immediate retaliatory launching.

Single Command Concept

Whether for conceptual problems such as this one, or for challenges in design or manufacturing, AMF has ingenuity you can use. AMF people are organized in a single operational unit offering a wide range of engineering and production capability. Its purpose—to accept assignments at any stage from concept through development, to production, and service training...and to complete them faster in

- *Ground Support Equipment*
- *Weapon Systems*
- *Undersea Warfare*
- *Radar*
- *Automatic Handling & Processing*
- *Range Instrumentation*
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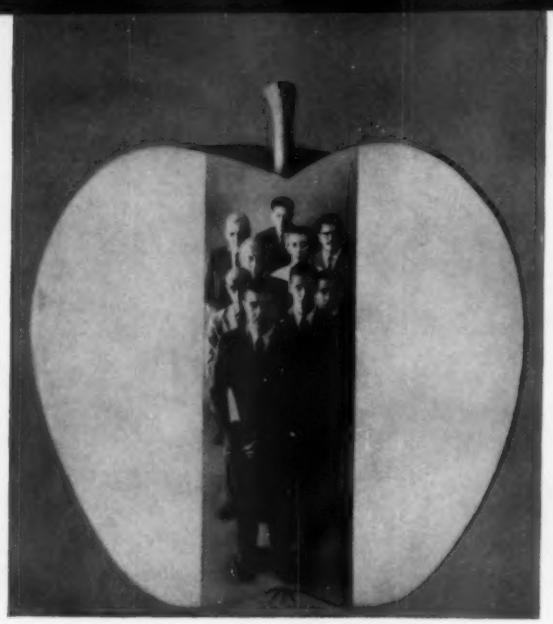


"CORE CONCEPT"—NEW APPROACH TO SYSTEMS MANAGEMENT AT S-C

A basic problem in Systems Management has grown out of the one-shot nature of each project. In many cases, after the system is delivered, the team dissolves. Then, when a new Systems project is initiated, the process of assembling a Systems team starts all over. This consumes time, effort and money.

We've done something about this at Stromberg-Carlson. We've created a new approach to Systems Management.

We call it the Core Concept.

We've built a *permanent* managerial staff. Because it is permanent, we've been able to bring in top talent in engineering, supervision, research, accounting—men with the ability and experience to handle major projects simultaneously or successively.

POINTS OF DEPARTURE

in SYSTEMS MANAGEMENT

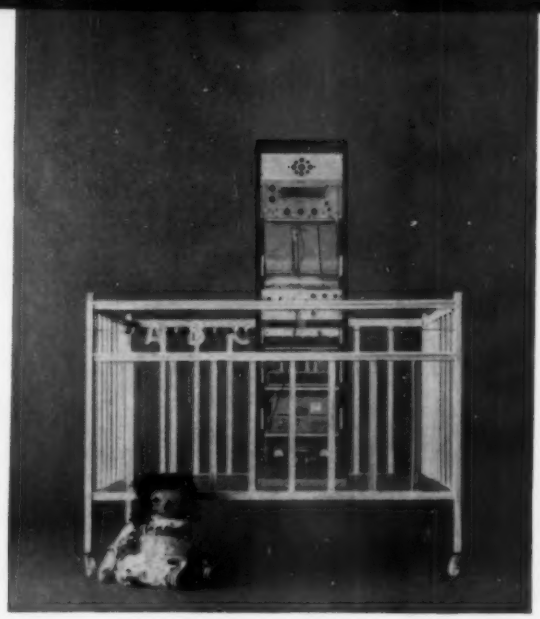
And we've also assembled a group of prime capability sub-contractor companies—*in advance of systems proposals.* As a result, we are able to get projects off the ground faster, to carry them to successful completion with a minimum of lost time or effort—*at a lower cost to Government.*

Right now, in fact, Core Concept is speeding the development of the On-Site Titan Command System and of a new, highly classified ground passive reconnaissance system, to name two of Stromberg-Carlson's Systems Management assignments.

As a leader in electronics and communications, we're qualified to take over additional systems management responsibilities in undersea or CBR warfare, command control systems, and related areas.

Why not let our Systems Management people show you how Stromberg-Carlson's "Core Concept" can be put to work on your program?

STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**
1400 N. GOODMAN STREET/ROCHESTER 3, N. Y.



THIS BREADBOARD IS LEARNING TO TALK ... AND LEARNING FAST

No, it's not an exotic loudspeaker or other transducer we're aiming for in research at Stromberg-Carlson. It's an electronic device that can turn a coded signal into actual speech. Why?

Well, by encoding your voice for transmission along a channel many magnitudes narrower than that occupied by the original speech sound wave ... and by synthesizing this signal back into speech at the other end ... we can cram many messages into a given circuit capability, frequency range or bandwidth.

This program demands probing beneath classical phonetics into the very psychological and physiological mechanisms of human communication. It requires mathematical analysis of speech patterns, and it calls for new computer logic.

in COMMUNICATIONS RESEARCH

Already, this research program is well advanced. This year we should complete analysis equipment and partial analysis of speech signals.

A machine that speaks is only one of Stromberg-Carlson's current objectives in research. A random sampling might spotlight such projects as these: Studying and evaluating solid-state materials and devices to meet the requirements of specific radio frequencies. Adding to our basic knowledge of data transmission in order to increase speed and reliability, at lower costs. Enhancing our knowledge of thin magnetic or dielectric films and their application to high-speed access storage systems. Tailoring solid-state molecules into super-sophisticated circuits or circuits not previously possible. In short—we're interested in anything that will lead to a better understanding of electronics and communications—terrestrial, maritime, or celestial.

HOW TO ELIMINATE 99 OF EVERY 100 MINUTES IN SYSTEMS TESTING

SCATE—Stromberg-Carlson Automatic Test Equipment—is just what the weapons system engineer ordered. It is very likely the most advanced, and fastest test equipment available today.

Programmed with punched Mylar tape, SCATE tests an unprecedented number of parameters, makes marginal and contour tests, isolates specific faults, detects performance degradation, predicts probable sources of failure, continuously checks itself, displays a rapid HI-GO-LO and numerical evaluation for each test and prints a permanent record ... all in record-breaking time.

SCATE pays off in flexibility and economy, too. Standard building-blocks—solid-state modules using proven, reliable circuits—form the nucleus of the

in ELECTRONIC EQUIPMENT

basic SCATE system. Unique blocks—special stimulus generators and response normalizers—custom-tailor SCATE to the particular test requirements of any missile, aircraft or ground electronic system. And that old bugbear of test equipment—development changes in weapons systems—is no problem at all. Substitution of certain modules keeps SCATE up-to-the-minute, matching any weapons system from prototype to operational status.

Speed? 7000 bits per second. Recently, in a classified area, SCATE reduced a 12-hour manual testing program to less than 5 minutes. This represents a time reduction of over 99%.

In sum, SCATE is the only automatic test equipment that delivers these four critical advantages: (1) fault isolation, (2) self-testing, (3) complete solid-state modularization and (4) in-development flexibility. Descriptive literature on request.

MISSILES AND SUPPORT EQUIPMENT

Alfred J. Zaehringer

Air-Launched Ballistic Missile.—The Air Force is putting increased emphasis on getting its air-launched ballistic missile, Skybolt, into operation by 1964. The ALBM is designed for launch from either the United States B-52 or the British Vulcan bombers. The purpose of the ballistic missile is to allow delivery of nuclear weapons to a target some 1,000 nautical miles from the launching aircraft. Present views of the all-solid-propellant rocket are still vague. However, it is believed to have two stages, a maximum diameter of three feet and an over-all length of approximately thirty-five feet.

Launching conditions will be quite different from those of ground-launched ballistic missiles. The launching plane will be flying at a speed of Mach 0.75-0.80 and at altitudes of 35,000 to 40,000 feet. The missile is first dropped from the plane like a bomb. When a safe distance from the mother ship, the first stage ignites and pushes the missile forward. When the rocket is considerably ahead of the bomber, the missile turns up into a vertical climb and thenceforth operates like a typical ballistic missile in a predetermined trajectory.

A $380 million program is expected, and first tests will take place probably in Florida along the Atlantic Missile Range.

Blue Scout Fired.—The Air Force version of the Scout rocket series got off with a big bang when the Blue Scout was fired to Ascension Island from Cape Canaveral. A 32.8-pound payload is said to have reached a distance of some 16,600 miles into space before hitting its impact area some 7,000 miles from the launch pad. The Air Force is planning some thirty-five Scout shots per year. Early versions will be instrumented, but, later in the series, satellites will be launched with this vehicle.

The relatively low cost ($500,000 each) of the Scout is expected to enable many experiments to be carried on which were heretofore limited to the small number of available big boosters.

Mr. Zaehringer, president of the American Rocket Company, Wyandotte, Mich., is a recognized authority on astronautics, guided missiles, and jet propulsion.

Army Views Pershing.—Demonstrations of the mobility of the Pershing rocket system were recently held in Germany. The 2-stage solid missile can travel over rugged terrain on its tracked launcher-erector, the XM-474. The Pershing vehicle can move up to 40 miles an hour, and is capable of climbing over 3-foot obstacles.

The missile and vehicle constitute a complete tactical package that can be air-transported; in addition, the system can be carried by a helicopter. The 300-mile-range missile has a length of 34 feet and a diameter of 40 inches. Troops are expected to get the selective-range weapon around 1963.

Big Solid Boosters.—The National Aeronautics and Space Administration is embarking on studies which are expected to lead to large solid-propellant boosters which are in the Saturn or Nova liquid class. Two systems are being studied—one with a launch weight of one million pounds and the other with a launch weight of seven million pounds. It is stated that the solid units would allow a booster some thirty per cent smaller than a comparable liquid unit.

Liquid Fluorine Rocket.—An upper-stage rocket engine using liquid fluorine as the oxidizer and either liquid hydrogen or hydrazine is apparently near. Bell Aerosystems reports progress on its 15,000-pound-thrust fluorine/hydrogen engine. The new engine would give an approximate fifty per cent performance increase over the conventional liquid-oxygen/liquid-hydrogen engine. Meanwhile, Rocketdyne is making ready its 15,000-pound-thrust fluorine engine, Nomad. These engines are believed to offer the ultimate in chemical-propellant rockets.

Nuclear Rocket.—NASA is looking beyond the ultimate in chemical rockets to nuclear power to provide large payload capabilities in orbit. The heat-transfer type of reactor is looked on with favor in conjunction with a liquid-hydrogen working fluid. The nuclear "fuel" either would be dispersed in graphite reactors or would use tungsten elements in beryllium reactors.

Target Missile.—The Army is to begin testing its Redhead-Roadrunner target missile. The same missile can be used for either high- or low-level controlled missions. The craft will be capable of flying from subsonic speeds through Mach 2 and from ground level to 50,000 feet. It will be ground-launched by a solid-propellant rocket booster. Powered sustaining flight will be via a ramjet engine. The new system will be less than nineteen feet long and have a diameter of only one foot.

Removable triangular wings will measure some 6 feet across, and twin stabilizers will have a span of 3½ feet. The booster rocket is located under the fuselage while the ramjet engine is on top. The solid booster has a thrust of 6,000 pounds for 5 seconds. Contract for production will total nearly $4 million.

Antimissiles.—Increased development of the antimissile-missile concept continues by the Army. In September 1960, an improved Nike Hercules missile intercepted and destroyed another missile of about the same type some 19 miles above the earth. The test was carried out at the White Sands Missile Range in New Mexico. In a previous test, the Nike Hercules downed a Corporal missile.

On September 30th, the Army announced that it was investing an additional $199,125,000 in development of its Nike Zeus "anti" system. The supplemental contract will permit development of the system for another twelve months. The Nike Zeus system is designed to use advanced radars and electronic computers to detect and track ballistic-missile warheads, discriminate between real warheads and decoy devices, and then launch and control Nike Zeus missiles to intercept the attacking missiles and render them ineffective.

The first prototype model of a target intercept computer for guidance has just been installed at White Sands. The computer is considered the fastest and most reliable ground-guidance computer so far developed in the Nation's defense program.

Through built-in error-detection circuits, the computer continually checks itself. If an error is discovered, it gives a signal and automatically isolates the error to a specific location. The modular construction of the nearly 175,000 basic components of the computer makes possible fast and easy repair. A basic module can be replaced in less than five minutes.

small world, isn't ITT

with its capacity for <u>total</u> Communications–ITT is helping to shrink our rapidly expanding Universe!

Communications can be briefly defined as the business of getting information from Here to There—and from There to Here. Every improvement in Communications brings Here closer to There. And that's the business ITT is in—narrowing the gap between Here and There, whether There is a nearby city or a nearby planet.

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ARMAMENT ELECTRONICS

Traver B. Van Vliet

Frequency Diversity Radar.—A technique to shift radar instantly and automatically to a different frequency, thus reducing vulnerability to enemy jamming, has been developed by General Electric Company. The company has proposed to the Air Force and Navy a 20-pound adapter to give existing interceptor fire-control systems this advantage. The Navy will evaluate the adapter on radar modified by GE.

Microwave Transistor.—A new transistor, capable of operating in the ultra-high and microwave frequency ranges, will be produced by Hughes Aircraft Company. When tested in a microwave mixer-oscillator circuit at four kilomegacycles, the transistor operated with ten per cent efficiency. The company is striving for a transistor operating up to ten kilomegacycles with the same ten per cent efficiency. The parametric mode transistor was invented at Lenkurt Electric Company, a subsidiary of General Telephone and Electronics.

Galactic Noise Studies.—Under contract from Wright Air Development Division, the Ewen Knight Corporation will study characteristics of 24-kilomegacycle ammonia line radiation from galactic radio sources. The technique may find use in space navigation and guidance.

WWV Time Code.—Station WWV, the audio and radio frequency standard operated by the National Bureau of Standards, has added to its regular transmissions of time and radio propagation data a binary timing code which could be used to synchronize satellite sightings and other observations. The timing code, used on an experimental basis, is broadcast for one-minute intervals ten times an hour.

Space Telemetry.—Wright Air Development Division is sponsoring development by Watkins-Johnson Company of a traveling wave tube amplifier-oscillator for space telemetry. Design calls for operation in the 2,000- to 2,400-megacycle range with 10 to 15 watts output at 30 per cent efficiency. The tube will weigh less than a pound and will have a life of over 10,000 hours.

Electronic Image Identification.—A machine which can identify between different-shaped objects, without previous knowledge of them, the Mark I Perceptron, has been developed by Cornell Aeronautical Laboratories, Inc. Work on the Perceptron is being sponsored by the Office of Naval Research and the Rome Air Development Center. Although the present model is relatively simple, a more advanced model could be used to identify aerial objects whose shapes mark them as targets. The Perceptron is "taught" to identify objects much the same as a child learns. If at first the machine identifies an object incorrectly, the operator "instructs" the machine on the correct identification. The company reports that, with corrective training, accuracy of the machine is 100 per cent.

German IFF.—The Federal Republic of Germany has awarded a contract to Packard Bell Electronics to manufacture identification friend or foe (IFF) sets for installation in first-line defense aircraft. The contract also requires the company to send engineering personnel to West Germany to install the equipment and to instruct German personnel in its operation and maintenance.

Low-Cost Scatter System.—A low-cost, lightweight tropospheric-scatter communication system, capable of transmitting teletype and other digital data at distances up to 500 miles, has been developed by General Electric. The "thin-route tropo system," can transmit on six 100-word-per-minute teletype channels using an 800-cycle bandwidth. The system uses small yagi-array antennas and transmitters rated at 500 watts and under. This is in contrast to the DEW Line, which employs antennas as large as 120 feet high, and transmitters rated in kilowatts.

Solid-State UHF Generator.—A solid-state UHF generator, which can deliver one watt at 1,000 megacycles, has been developed by Pacific Semiconductors, Inc. The generator uses transistors and silicon high-Q voltage-variable capacitors. The development may give tubes strong competition in the UHF field.

Orbital Radio Reflector.—The Department of Defense is sponsoring study by Massachusetts Institute of Technology in the use of an orbital radio reflector made up of thousands of tiny frangible metal needles fanned out to provide an extremely large reflecting surface. The needles would present no collision hazard and would not interfere with radio astronomy or space communications.

Semiconductor Cathodes.—The U. S. Army's Signal Research and Development Laboratory is studying the use of semiconductors for electron emission in electron tubes in place of the conventional heated cathode. Although the heated cathode makes operation of the vacuum tube possible, it uses up considerable power and is usually the cause of tube failure. Its elimination would reduce required power, increase reliability, and lessen the need to remove heat developed by the cathode. The work being done is not in developing new devices, but in reaching an understanding of electron emission from semiconductors.

Nuclear Space Ship.—A space vehicle operating under full thrust for the two years necessary to carry it to the planet Jupiter, with enough residual power to operate its instruments for several years thereafter, was revealed by Lockheed Missiles and Space Division. A nuclear-thermionic-ionic propulsion system is designed to provide a continuous power supply by direct conversion of heat to electricity. The entire system, designed without any moving parts, will operate unattended in space with little likelihood of failure.

The key to the whole system is a series of small nuclear reactors about two feet in diameter producing 1,200-degree-centigrade temperatures to banks of thermionic generators which convert the heat directly into electrical energy for the ion-beam motors. With such a system, using cesium vapor as fuel, 110 pounds of propellant could deliver an equal weight of payload to Jupiter.

Mr. Van Vliet is a student of engineering and mathematics. He is active in amateur radio and also in experimental electronics.

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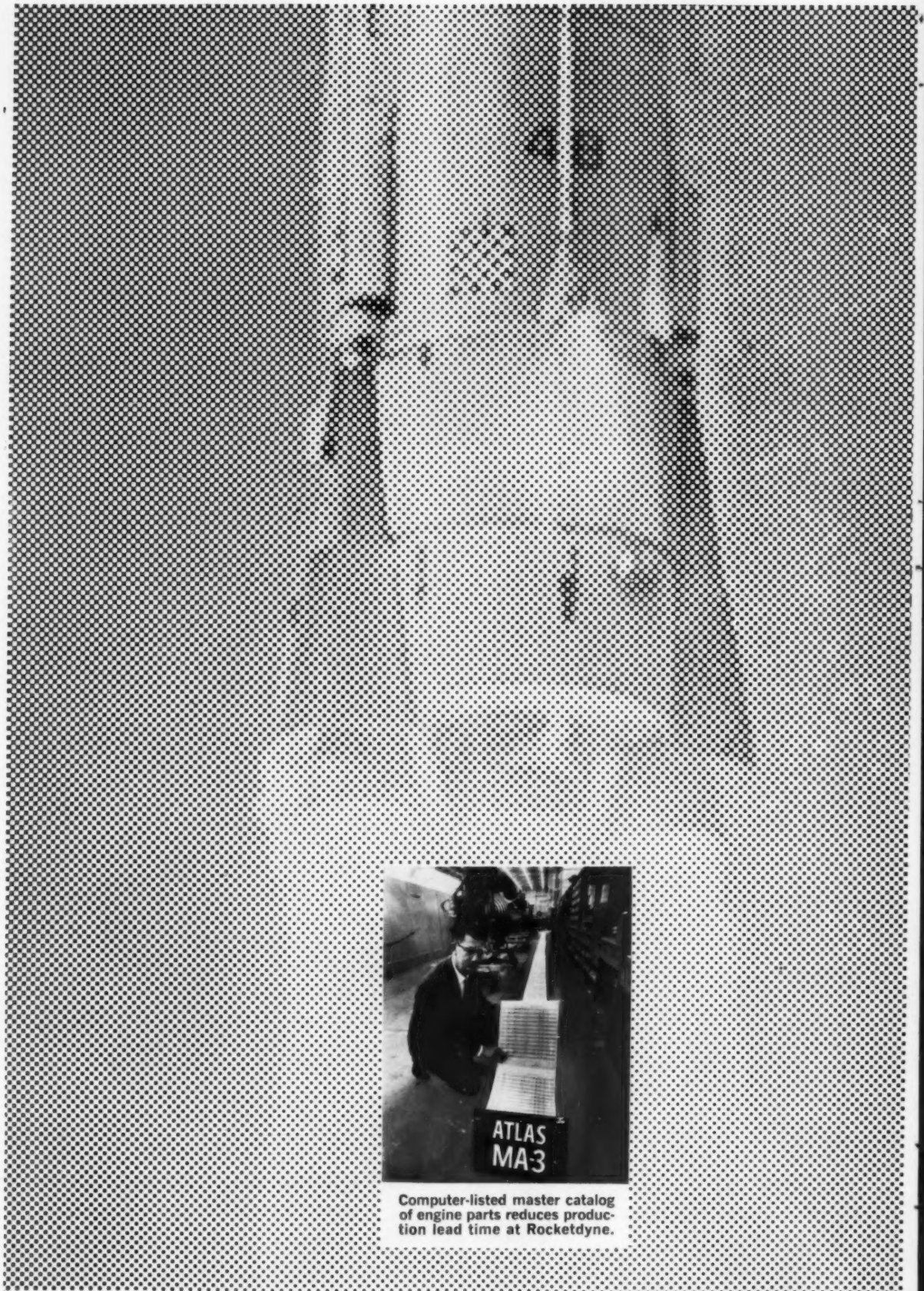
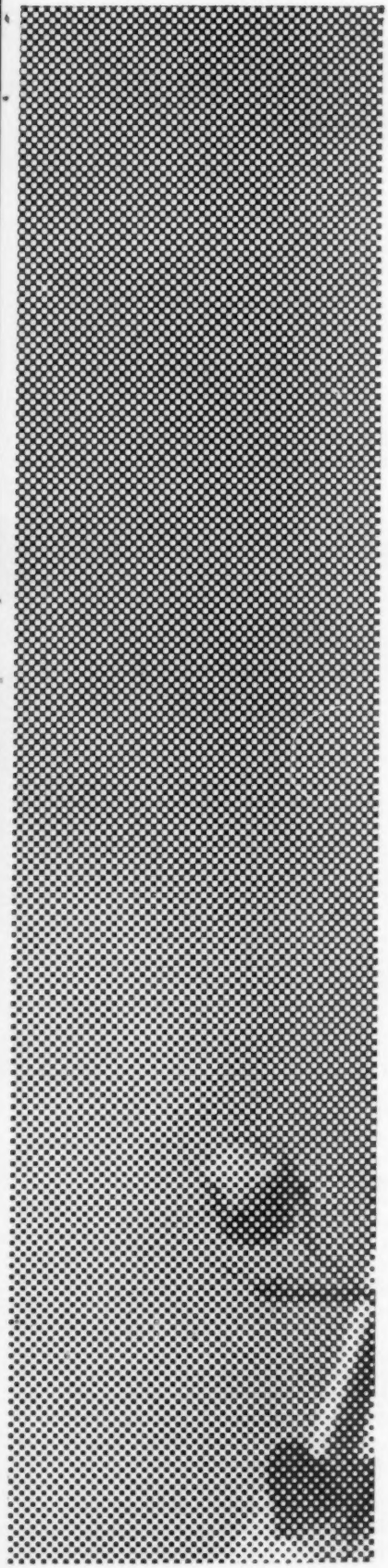


Computer-listed master catalog of engine parts reduces production lead time at Rocketdyne.



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25 of America's 28 successful satellites and space probes have been launched by Rocketdyne engines.

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Book REVIEWS

Reviews in this issue by:

COL. GEORGE S. BRADY, *consulting engineer, author, editor, Washington, D. C.*

LEO A. CODD, *editor, Washington, D. C.*

F. W. FOSTER GLEASON, *military historian, ordnance analyst, editor, Washington, D. C.*

COL. CHARLES MCKNIGHT, *ordnance engineer, metallurgist, historian, and former company executive, Fork, Md.*

W. H. RUSSELL, *educator, historian, Annapolis, Md.*

The War Memoirs of Charles de Gaulle—Salvation, 1944-1946. New York: Simon & Schuster, Inc. 346 pp. $6.

THIS volume completes the memoirs thus far of General de Gaulle. Since it was written, he has returned to public life, and it is to be hoped that other volumes will follow in which he will take up the narrative of the momentous present. The first of this series was entitled, "The Call to Honor"; the second, "Unity." Combined, the three are history of great consequence —told with the simplicity of the soldier and the beauty of artistic authorship.

About half of the present volume relates to the immediate problems of the restoration of order in France after its liberation in 1944. The relationships between General de Gaulle and the Allied commanders, his imperturbable insistence upon the right of the French people to control their own destinies, the complications of restoring order in the midst of such material and psychological confusion, all comprise an epic which clearly marks General de Gaulle as one of the great military and political leaders of world history.

The remaining part of the book is a sad commentary. In it is described the victory of the politicians of France pulling at cross-purposes with ever-increasing vigor which finally led De Gaulle to retire in 1946. He returned to his little village, there to contemplate with sadness the path his beloved country had embarked upon. In the light of what has happened to him and to France in later years, there is both prophecy and fulfillment in many of his philosophic observations.

What General de Gaulle has written here proves many things, not the least of which is the basic patriotism of the French people as well as his own genius for generalship in war and leadership in peace. His clear analysis at the time of many of the events as they happened show an understanding of human nature which not all the Allied leaders in World War II possessed in the same high degree.

He saw at once the crafty maneuverings of the Russians for their own advantage. He criticized the Churchill government for the near outbreak of fighting between the French and British troops in Syria to gain dominance in the Middle East. He characterized our American leaders as bearing scant good will toward France.

Here is history of the first rank which deserves to be studied carefully if the mistakes it records are not to be repeated in the immediate or distant future.—LEO A. CODD.

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It makes certain that only aircraft with properly operating weapon control systems are sent on missions. Based on a building-block design employing the highest reliability factors, a mechanical programming device and self-test capability, DATS utilizes a series of synthesized attack runs typical of mission conditions. DATS could be made applicable to many interceptor types of aircraft.

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Book Reviews (Contd.)

Victory in the Pacific, 1945. History of United States Naval Operations in World War II, Vol. XIV. By Samuel Eliot Morison. Boston: Little, Brown and Company. 407 pp. $6.50.

SAMUEL Eliot Morison, most popular of the serious naval historians since Mahan, concludes here a project he undertook eighteen years and fourteen volumes ago—"The History of United States Naval Operations in World War II." Ending as it does the strictly contemporary narration of naval action in World War II, this volume marks the passing of an era that began on December 7, 1941, and caps the career of an historian almost literally bred as its chronicler.

In the main, this volume narrates the naval amphibious assaults of Iwo Jima and Okinawa. Each narrative reflects the thoroughness with names and numbers, the concise story, and taut conclusions that Morison's readers recognize as the hallmark of his long series. As a bonus, the Okinawa story has a valedictory quality that will strike a responsive chord among those who knew the Pacific war at first hand.

By comparing Morison's account of Okinawa with what he wrote about Guadalcanal and the North African invasion, a reader perceives the maturing of amphibious skills among the U. S. naval services. Though they used at Okinawa the same general doctrine underlying the pioneer effort at Guadalcanal, each amphibious echelon—from the earliest air reconnaissance, through naval gunfire support, ship-to-shore movement, and close air-support, to a balanced Fleet Marine Force of all arms—demonstrated at Okinawa refinements of the amphibious art undreamed of two years before.

Though they are handled in spare language, the volume does abound in analytical conclusions—albeit the now-mellowed Morison tends to emphasize praiseworthy achievement while remaining relatively silent on lessons about what not to do next time.—W. H. RUSSELL.

Of Mice, Men and Molecules. By John H. Heller. New York: Charles Scribner's Sons. 176 pp. $3.95.

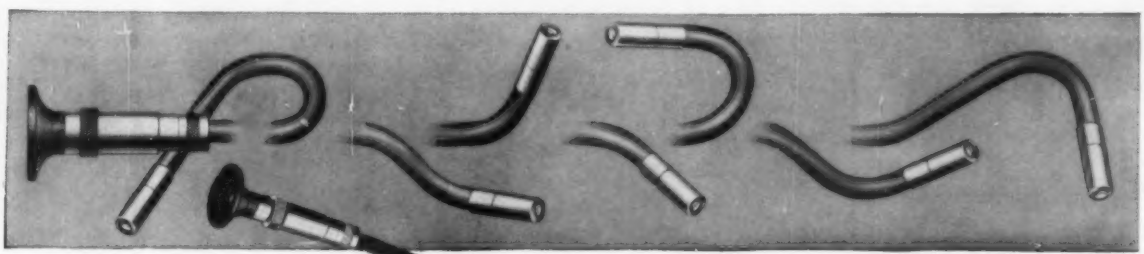
STARRY-EYED man now stares through fog toward the infinity of space, enchanted by the prospects of more worlds to conquer. Perhaps he would be disenchanted, but he would find more of promise if he would lower his eyes and examine his little personal cosmos. There he would again encounter the infinite, but this time the infinitely small, with which he lives and moves and has his being and of which he is grossly ignorant. These little things are the atoms and the electrons, the molecules and the living cells that make up his body and brain.

They and their effects for good or evil on the human being are the subject of Dr. Heller's interesting and exciting book. He reviews past progress in the science of life and discusses current biological research with its triumphs and tribulations. He then plays the prophet with his expectations and predictions for the future of this research. In doing this, he deals with such provocative matters as moods and madness, sharks and electric eels, cellular siege warfare, radiation and radiofrequency, and thimbles of poison.

After this varied fare, Dr. Heller, practicing his profession of basic medical researcher, takes a look at the future as "through a glass darkly" and leaves the reader at book's end in a perplexity of thought-provoking, debatable questions. —CHARLES MCKNIGHT.

Countdown for Decision. By Maj. Gen. J. B. Medaris, U.S.A. (Ret.), with Arthur Gordon. New York: G. P. Putnam's Sons. 303 pp. $5.

BRUCE Medaris has a keen mind matched by boundless energy and drive. His record in the missile program gives abundant proof of that. Little wonder, then, that his book makes fascinating reading. In its pages he recounts his



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NEWS: **Before 11:00 a.m. on the first day of the NMTB Exposition in Chicago, September 6, 1960, a Fort Wayne, Indiana manufacturer bought a similar machine being demonstrated in the Sheffield booth. Additional orders continue to come in.**

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missile activities—the many internecine battles he won for the Army, those that he lost, and the over-all gigantic advances on the missile front. Throughout the text there are comments and proposals he is most certainly qualified to make. His style of writing is as crisp as his delivery on the public platform. "Countdown for Decision" is a book to be read and studied as much for its wisdom as well as the description of the futilities, lost motion, and bureaucratic absurdities it describes. He cites chapter and verse.

What General Medaris has written covers a multitude of topics familiar to the Ordnance fraternity. He pleads for the delegation of authority to field commanders. He comes out strongly for the arsenal philosophy of weapons research and engineering. He favors the lawyer rather than the businessman in the role of high Defense official.

He bemoans the outrageous, unproductive overhead costs of estimating, budgeting, investigating, auditing, and the interminable briefings. He decries the authority given the Bureau of the Budget in military decision-making.

He criticizes the childish policy on news releases by responsible service officials. He wishes that the hours and days that must be spent cooling one's heels awaiting the pleasure of congressional committees might be utilized in doing the work that is crying to be done.

He castigates the downgrading of the services—especially the Army—and the limitation of their authority. He describes vividly the evils of overcentralization. There is also a thrilling account of a missile countdown.

But over and above all this is the portrayal of Army successes in the missile program. General Medaris recently climaxed a long military career as commanding general of the Army Ballistic Missile Agency at Huntsville, Ala. As commander of the U. S. Army Ordnance Missile Command at Redstone Arsenal he carried forward the great work of his predecessors—Generals Thomas K. Vincent and Holger N. Toftoy—in backing up the best space team in the world led by Wernher von Braun.

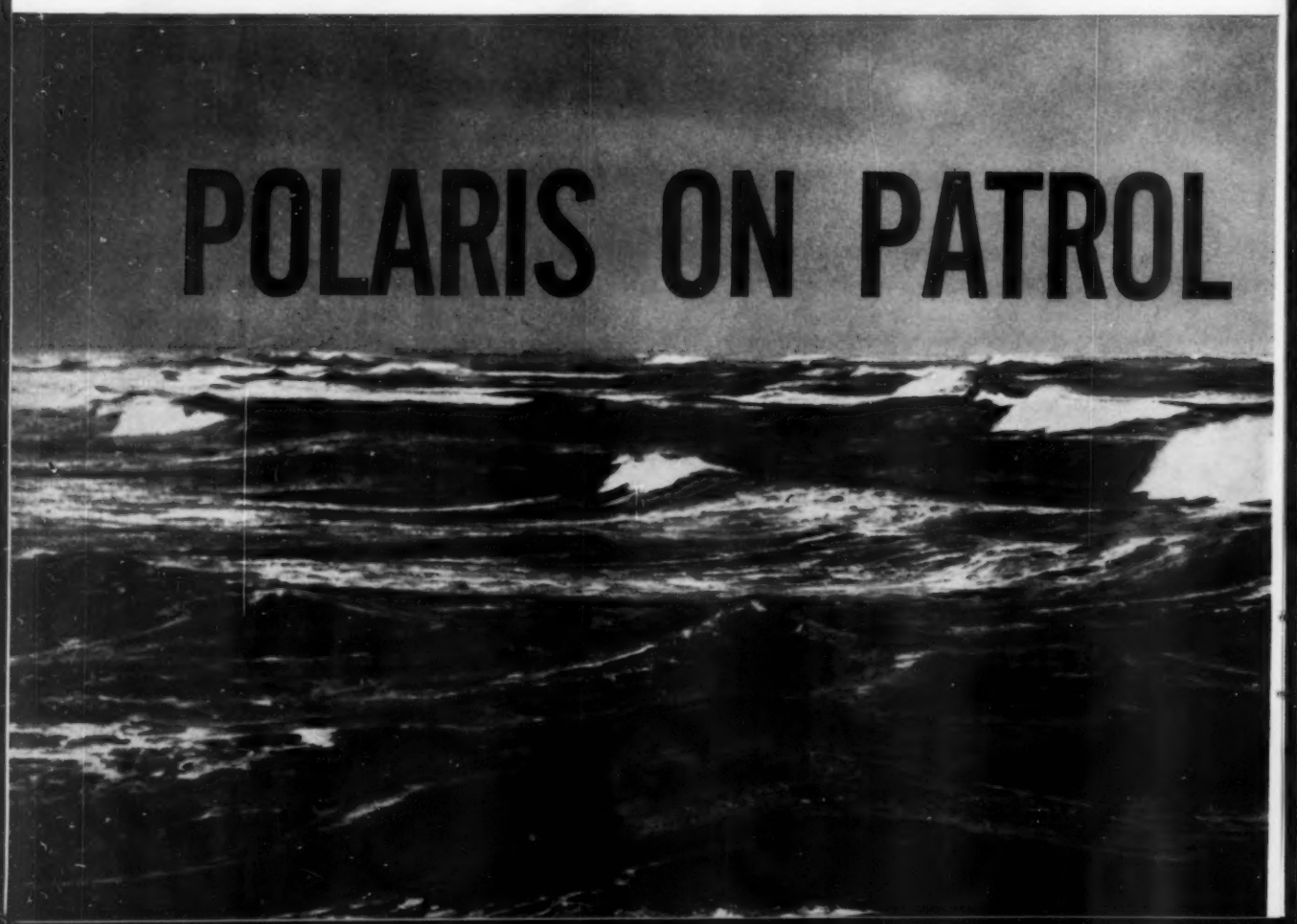
But the Medaris thesis is by no means mostly criticism of conditions as they are. He does not belabor the forces of delay and waste without suggesting remedies. Some of the latter, such as disposal of surplus facilities, are steps to be taken piecemeal as the need arises. It is refreshing and constructive to have the case stated. This, in itself, should lead to corrective measures.

This book is a major contribution to the development of policies and practices in the progress of our defense posture in the Space Age. While there will be many to differ with this or that item in the Medaris recipe for American military-industrial leadership, none can deny and many will praise the Medaris bravery in sticking to his beliefs, and in the soundness of most of them. Many of these beliefs, so cogently stated, our people will neglect to follow at their peril.—Leo A. Codd.

Management of Nuclear Materials. Edited by Ralph F. Lumb. Princeton: D. Van Nostrand Company. 516 pp. $16.50.

THIS book does not make easy reading for the ordinary procurement official dealing with conventional industrial materials, but it should be invaluable to anyone in a responsible position connected with an atomic-energy plant, whether on a submarine or in a power station.

The handling of SS (source and special nuclear) materials is necessarily a more complex and scientific task than that of ordinary materials, and this volume describes in detail the system for handling nuclear materials as developed over a period of thirteen years by the United States Atomic Energy Commis-



sion. It gives the methods of purchasing, recording, testing, and storing, but also goes further than an ordinary procurement manual in giving much space to enrichment procedure, fabrication of reactor fuel elements, and recovery of fuel and scrap.

The book, although printed privately, is actually an official publication, supervised by the Atomic Energy Commission, and all royalties from its sale go to the United States Government. The twenty-six contributing authors are well-qualified authorities and have been actively engaged in the highly specialized work of nuclear materials management at the various nuclear plants and laboratories. It is a "must" volume for the libraries of all nuclear plants.—GEORGE S. BRADY.

Grape and Canister: The Story of the Field Artillery of the Army of the Potomac, 1861-1865. By L. Van Loan Naisawald. New York: Oxford University Press. 593 pp. $10.

THE author, a graduate of V.M.I. and an officer of artillery, 1941-1946, has done for the Northern guns what Wise's "Long Arm of Lee" did for the Southern. Aided by a flowing style, solid research, and the knowledge of the intervening years, it compares most favorably with the work of 1915.

The technical points of ordnance are in an early chapter, an appendix, and scattered throughout the text. Together, they form a complete and accurate record, though the work lacks the tabular precision and profuse illustration of the American Ordnance Association's two précis recently published on this subject. —F. W. FOSTER GLEASON.

BOOKS RECEIVED

Controlled Thermonuclear Reactions. By Samuel Glasstone and Ralph L. Lovberg. New York: D. Van Nostrand Company. 523 pp. $5.60.

Delayed Effects of Whole-Body Radiation, The. Edited by Bernard B. Watson. Baltimore: Johns Hopkins Press. 80 pp. $4.50.

Every Serviceman's Lawyer. By Earl Snyder. Harrisburg: The Stackpole Company. 341 pp. $3.50.

Flight Facts for Private Pilots. By Merrill E. Tower. Los Angeles: Aero Publishers, Inc. 216 pp. $5.00 (hard cover), $3.50 (paperbound).

Illustrated Firearms Assembly Handbook. Washington: National Rifle Association of America. 160 pp. $3.50 (to nonmembers), $2.50 (to members).

International Missile and Spacecraft Guide. By Frederick I. Ordway, III, and Ronald C. Wakeford. New York: McGraw-Hill Book Company. 411 pp. $25.

Introduction to the Gas Turbine. By D. G. Shepherd. New York: D. Van Nostrand Company. 300 pp. $7.75.

Magnetic Amplifiers, Principles and Applications. By Paul Mali. New York: John F. Rider Publisher, Inc. 112 pp. $2.45.

NRA Gun Collectors' Handbook. Washington: National Rifle Association of America. 48 pp. $2.50 (to nonmembers), $1.50 (to members).

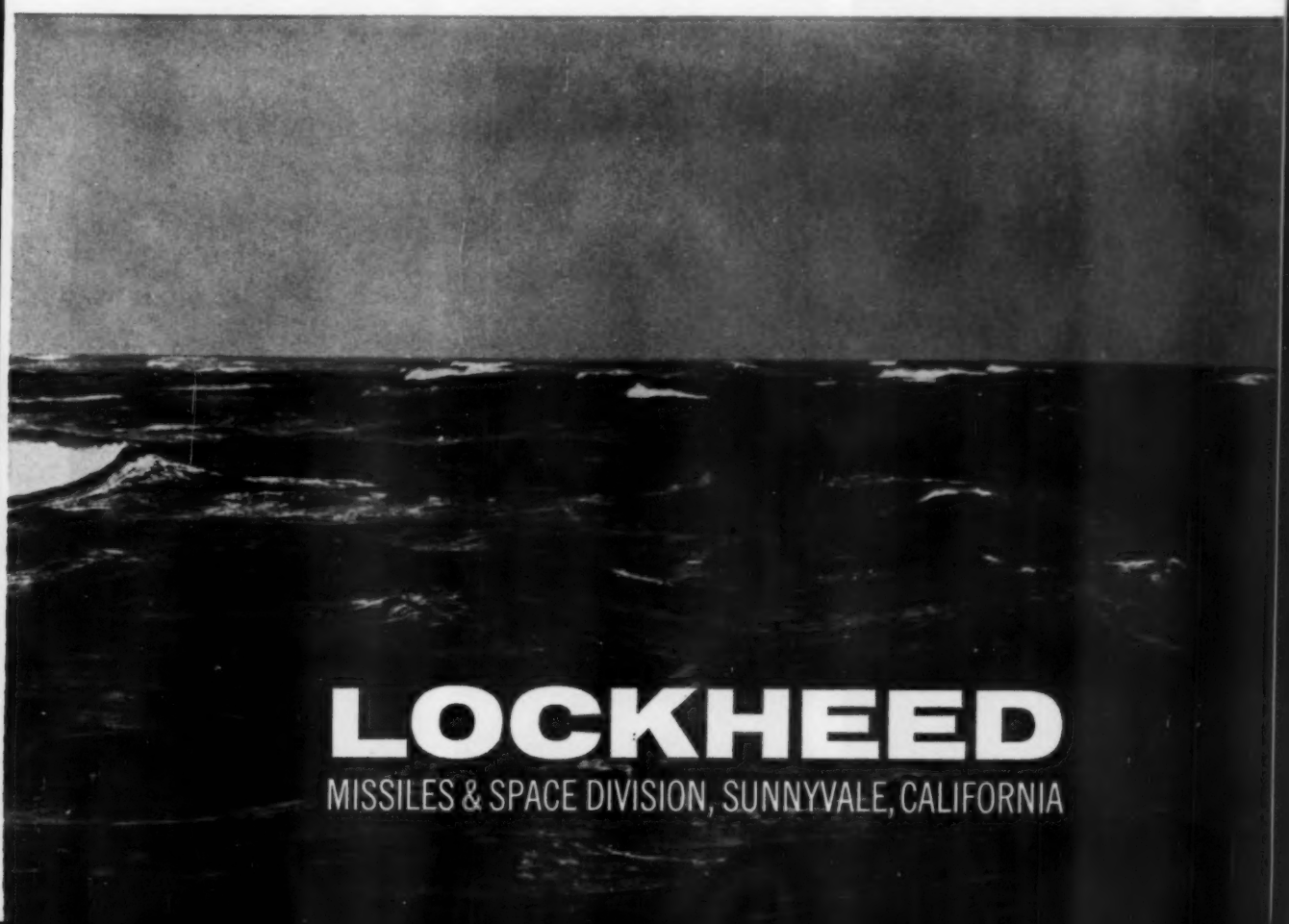
"Of Garryowen in Glory." By Lieut Col. Melbourne C. Chandler. Annandale, Va.: Turnpike Press, Inc. 500 pp. $10.50.

Statistical Processes and Reliability Engineering. By Dimitris N. Chorafas. New York: D. Van Nostrand Company. 438 pp. $12.75.

Torch to the Enemy, A. By Martin Caidin. New York: Ballantine Books. 158 pp. $0.50 (paperbound).

Transistor Circuit Analysis and Design. By Franklin C. Fitchen. New York: D. Van Nostrand Company. 356 pp. $9.

Video Tape Recording. By Julian L. Bernstein. New York: John F. Rider Publisher, Inc. 272 pp. $8.95.



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COMPLETE MARKETING ASSISTANCE. Kaiser Aluminum offers market information and assistance to companies interested in diversifying into the defense market and to companies already in defense work who are interested in other phases of the market.

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This means we can help you evaluate specific business opportunities and industry trends in terms of your company's manufacturing and marketing goals.

BID ASSISTANCE. As another customer service, Kaiser Aluminum offers skilled assistance in bidding defense business. Through our field offices, we offer you information on current bidding and bid results on many projects.

In addition, we can help you prepare defense bids by defining and describing items to be bid, by assisting with material take offs, and by recommending aluminum alloys and production methods best suited to a profitable bid.

TECHNICAL ASSISTANCE. Our experienced aluminum designers and product engineers are available to work with your engineers on any problem concerning aluminum design and fabrication. Often, their specialized knowledge of aluminum can be effective in arriving at an efficient and economical design solution.

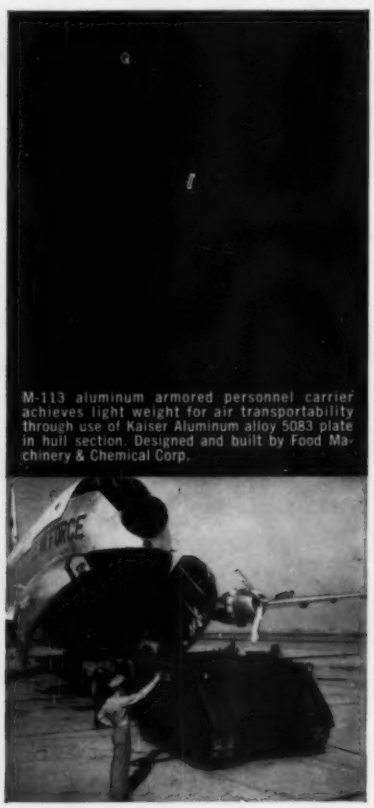
We also have available specialists in welding, machining, forging, casting, forming and other fabricating methods. When metal forming, joining or finishing problems arise, these technicians are available at no cost to you for consultation with your production and technical people.

METALLURGICAL ASSISTANCE. Kaiser Aluminum operates a complete metallurgical research establishment at Spokane, Washington, and maintains specialized research facilities in California, Louisiana, Illinois and Rhode Island.

Our Department of Metallurgical Research conducts continuous research and testing resulting in new alloys, improved joining techniques and applications of particular value to the defense industry. For example, this Department has been instrumental in the development of alloys suitable for armor plate, and has conducted extensive armor research at its ballistic firing range at Spokane.

The Department of Metallurgical Research can help you solve a wide range of aluminum application and metallurgical problems.

U.S.S. Dewey, one of the Navy's newest missile-firing frigates, has a lightweight all aluminum superstructure constructed of welded, high magnesium aluminum alloys. Weight is cut two-thirds—over a 1,200,000 pound reduction. Built by Bath Iron Works, Bath, Maine.



M-113 aluminum armored personnel carrier achieves light weight for air transportability through use of Kaiser Aluminum alloy 5083 plate in hull section. Designed and built by Food Machinery & Chemical Corp.

Use of aluminum in M-60 tank contributes to greater cruising range and increased mobility. M-60 weights 51 tons—3,000 lbs. less than M-48 model. Road wheel hubs are Kaiser Aluminum forgings. Other aluminum parts: fuel tanks, fenders, turret platform floor and road wheel discs. Designed and built by Chrysler Corporation under direction of U. S. Army Ordnance Tank-Automotive Command, Detroit, Michigan.

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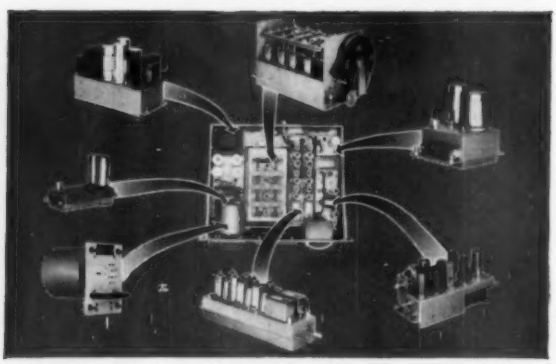

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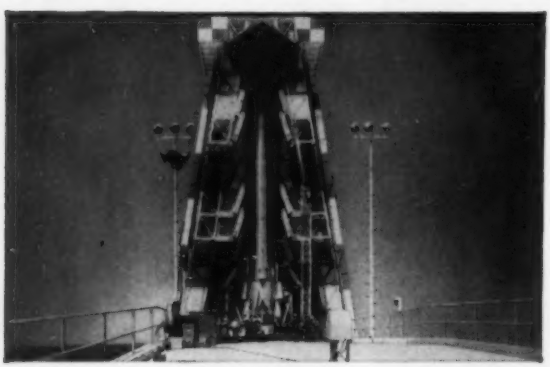

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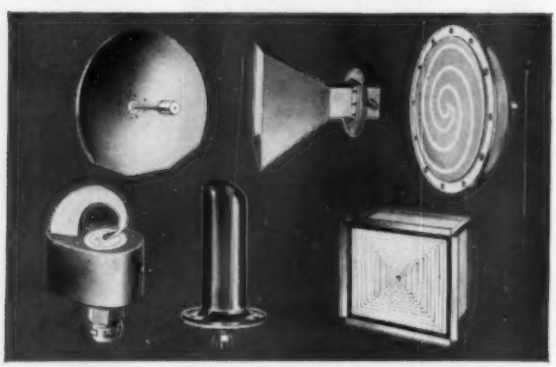

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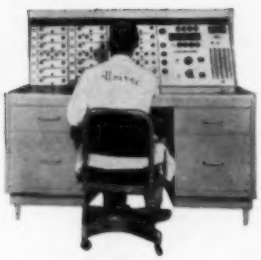

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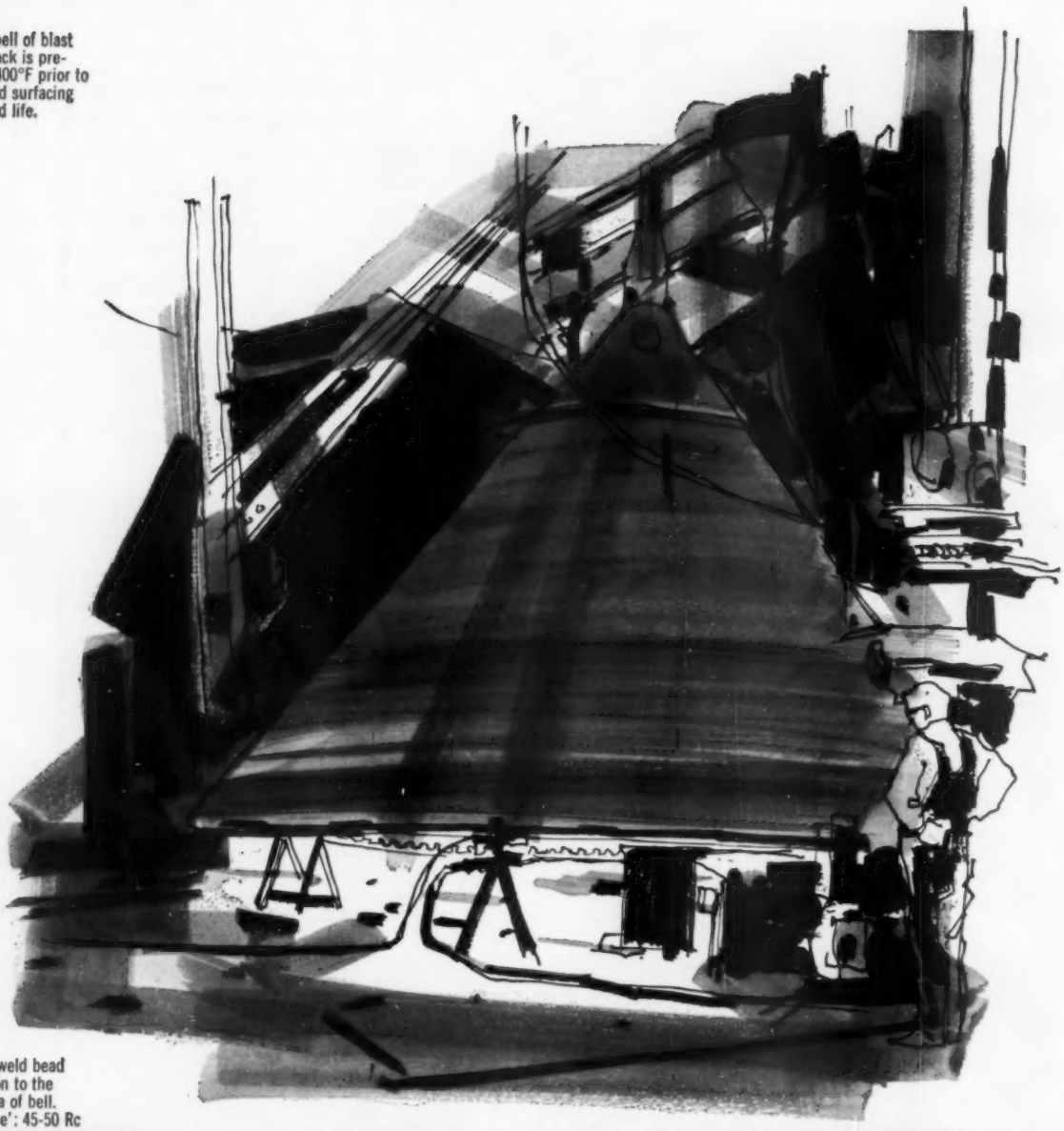

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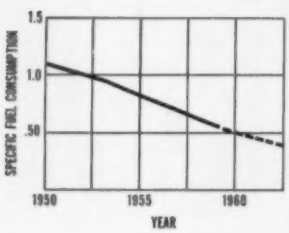
Small gas turbines soon to surpass piston engines for competitive applications

by Herbert Kunzel, President
Solar Aircraft Company
A Subsidiary of International Harvester Company

The gas turbine engine has made news this year as it has expanded into new and broader applications in the prime mover field. Behind this advance is continuing improvement in design and production. Even more advanced gas turbines will be developed in the next few years. In the small engine class (under 1000 hp) gas turbines will soon surpass overall piston engine performance and cost for competitive applications. They will also retain the inherent advantages of the gas turbine over the reciprocating engine.

One of the major reasons for this prediction is an impressive improvement in gas turbine economy. Previously, fuel consumption and high initial cost have kept the turbine out of all but selected power assignments. Industry and the military both thought the engines too expensive for most applications.



Through constant improvement, however, Solar has been steadily bringing simple cycle, small turbine specific fuel consumption down to an area competitive with piston engines. The fuel consumption of Solar's early 50 hp engines in 1948, for instance, was about 2.25 lb/hp-hr. The 1100 hp Saturn engine, which went into production this year, has the excellent simple-cycle fuel consumption of only .63 lb/hp-hr. Solar's experienced engineers improve life, "producibility," and performance characteristics with each new engine. At the same time, production costs are lowering rapidly.

Another significant advance in Solar turbine development has been the evolution of a unique design philosophy. Most gas turbines fall into one of two extreme categories: 1) Lightweight, high horsepower aircraft turbines, built to be as light as possible (about ¼ to ½ lb/hp), and 2) conventional industrial engines designed along the lines of steam turbines with a ratio of about 10 lb/hp. Both have inherent disadvantages. The aircraft turbines are relatively delicate with consequent problems of frequent overhaul and short life. Massive engine design, on the other hand, involves unnecessary bulk and difficulties with thermal lag and distortion. In either case, inherent advantages of the gas turbine engine are diminished and initial cost is adversely affected.

Solar's approach has been to develop a family of gas turbines that have both long life and light weight. The Saturn engine, with a weight-to-power ratio of 1.1 lb/hp, is heavier and more rugged than aircraft engines but much lighter than the usual industrial gas turbine. Although it is designed for long life, it has no more materials than are necessary to satisfy structural and thermal requirements.

Promising even further improvements in the turbine engine is the combination of Solar with International Harvester Company this year. IH saw the advantage of more power per pound several years ago. Their research and development has stressed performance and much work has been done by them on regenerative cycle turbines to reduce fuel consumption.

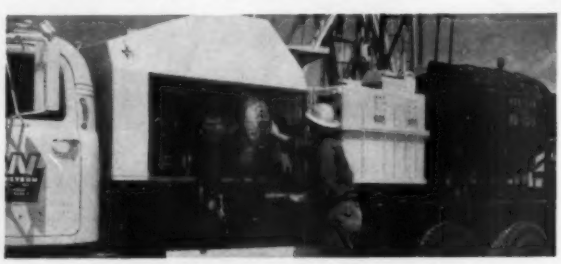
To basic research, they have added their many years of experience and leadership in high performance and low cost through efficient production of many thousands of IH engines for trucks, construction equipment and farm machinery.

Solar's successful Saturn engine development team and the combined research and resources of the two firms are now focused on further engine development in the area below 1100 hp. Preliminary design for a turbine in this range indicates that the following standards are feasible:

1. A life cycle equal to or better than conventional diesel engines—with considerably less maintenance.
2. Fuel consumption in the .4 to .5 lb/hr range.
3. Cost competitive to conventional reciprocating engines.
4. Inherent ease of starting and operation in a wide variety of climatic conditions.
5. Small size and light weight.

Developments like these are certain to continue the increase in turbine applications and use.

For additional information write to Dept. H-302, Solar Aircraft Company, San Diego 12, California.



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Armament Technology

This section of ORDNANCE contains selected papers on armament technology presented at meetings of Technical Divisions and Sections of the American Ordnance Association and contemporary articles on armament research, development, manufacture, and field use

Materials Make Missiles

High-temperature substances are the key to future propulsion progress

H. B. Porter and S. H. Herzog

U. S. Naval Ordnance Test Station, China Lake, Calif.

ONE hears and reads a great deal these days about theoretical super, "exotic," high-specific-impulse rocket fuels—so much, indeed, that it is easy to gain the impression that all that is necessary to attain space supremacy is to develop such fuels and build bigger chunks of equipment. This is reminiscent of the status of the "internal-combustion turbine" during the 1920's. Those who are old enough will remember discussions of the high efficiencies and high power-weight ratios theoretically attainable, and the vast possibilities that could be opened up, if. . . . At that point, the discussion usually ended on a sad note. Alas! There were no materials to withstand the high temperatures and erosion.

THE concept of the internal-combustion turbine was, of course, valid, and workable designs had been drawn. Many years elapsed, however, before sufficiently refractory materials were developed to permit the realization of that concept and to make possible the turbojet-propelled aircraft of today.

Spaceships utilizing fuels of fantastically high specific impulse at high efficiency are also valid concepts. The sad truth is, however, that they will continue to be just concepts until the development of materials having much better high-temperature performance capability than those currently available.

Any engine operating on thermodynamic principles, whether it be a rocket, a turbojet, or an "old-fashioned" reciprocating engine, must have available an appreciable temperature difference in order to operate with a reasonable degree of efficiency. In general, the efficiency of a heat engine may be increased by increasing the temperature difference within limits imposed by the design and by the physicochemical characteristics of structural material and fuel.

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IN a rocket, the temperature difference referred to above is the difference between the combustion-chamber temperature and the temperature of the exhaust gases as they leave the nozzle. Inasmuch as the "outside" temperature is substantially the same under all conditions, the temperature of the existing gases cannot be reduced below that given by an efficient nozzle. The only way to increase the operating-temperature difference in a rocket, therefore, is to increase the temperature in the combustion chamber by employing hotter fuels.

Propellant-flame temperatures of 10,000 to 12,000 degrees Fahrenheit—4,000 to 6,000 degrees above those of today—are anticipated for the foreseeable future. Higher temperatures, of course, mean an increase in the severity of the erosive environment. The best materials

now available for use in the nozzles and combustion chambers of even present-day rockets are only marginal in performance. Their operating life, only a few minutes, is a long way from that required for manned interplantetary flight, in which repeated firings of long duration will be necessary.

The most refractory materials known at present have melting points in the vicinity of 7,000 degrees Fahrenheit. With propellant temperatures constantly increasing, it is obvious that in the near future no materials now known will be able to confine and direct the flow of combustion gases.

A superficially obvious approach would be to make it possible to use currently available materials by simply preventing them from reaching temperatures that would substantially reduce their structural strength. Two possibilities, both of which have been explored and exploited, are:

1. Reduce the rate of heat transfer to the "hot" components (nozzles, jet vanes, combustion-chamber walls, etc.) by interposing a thermal-insulating material or a relatively cool film of gas or vapor between the components and the hot gases.

2. Provide a means for rapidly dissipating heat from the hot components through ablation, endothermic decomposition, or fusion and vaporization. These two schemes may be combined, under certain conditions.

In any case, the additional weight of expendable, nonthrust-producing material that must be carried by the missile reduces the motor performance index. Also, all the cooling methods so far devised—with the exception of regenerative cooling of the nozzles of liquid-propellant rockets—entail a considerable loss of energy from the propulsion system. In regenerative cooling, either the fuel or the oxidizer is first used as the coolant for the nozzle, then sent to the combustion chamber. Thus the heat extracted from the nozzle is returned to the system. This method, however, exacts a weight penalty in the form of plumbing.

FROM the foregoing, it should be apparent that these schemes should be regarded, not as true solutions, but rather as merely temporary expedients.

If exhaust-gas temperatures become high enough to produce (perhaps with the help of easily ionized fuel additives) a sufficiently high percentage of ionization, the nozzle can be protected by a magnetohydrodynamic constriction of the exhaust stream—again with a weight penalty. Magnetic and electrostatic fields do not, however, retard heat transfer by radiation, and highly refractory materials still will be necessary.

"Under prevailing conditions, it is possible to obtain data only in a piecemeal fashion. It is obviously difficult, or impossible, to incorporate such data into an organized body of useful knowledge. It is usually possible, when digging a ditch, to throw down one's shovel and resume digging at a later date without losing anything but digging time. Research and development, however, require a certain degree of continuity."

Despite the critical importance of materials, which should certainly be self-evident to anyone associated with the missile field, materials research and development is generally considered ancillary to other phases of a missile project. Too often the work is supported only to a point where a barely adequate material is developed, with no opportunity for further improvement, development of alternate materials, or cost reduction. The following is a case in point.

It is known that a molded glass-cloth phenolic laminate, when exposed to a high-velocity stream of hot gas, will erode much more rapidly when the surfaces of the laminations are parallel to the direction of gas flow than when they are oriented in such a way that the gas flows past their edges.

To make a nozzle insert for a certain rocket motor, a phenolic-impregnated tape of leached glass cloth (leached glass has a higher melting point than conventional glass) is first wound on a properly shaped mandrel in such a way that the successive layers overlap to give a "shingled" configuration, then molded into the nozzle. The inserts made in this way served satisfactorily in the rocket motor for which they were designed. They are very expensive, however, in both time and money.

Such expense can be justified only if there is no less-costly way of accomplishing the desired results. As of this moment, we do not know whether there is a more economical solution—and we are not likely to find out under existing conditions.

Progress reports on the development of most missiles show that the nozzle-insert material, for example, was selected by either the "cut-and-try" method or on the basis of its having been used previously in a somewhat similar rocket motor. A survey of the materials specified by various missile-development agencies indicates that each agency prefers certain materials almost exclusively.

In many instances, such preferences are supported by little more than a degree of familiarity with the preferred materials and a corresponding lack of familiarity with others. Further, there is little agreement among the various agencies as to the best materials for specific applications. Obviously, not all of them can be right—a fact which points to a lack of communication and coordination in the field.

UNDER prevailing conditions, it is possible to obtain data only in a piecemeal fashion. It is obviously difficult, or impossible, to incorporate such data into an organized body of useful knowledge. It is usually possible, when digging a ditch, to throw down one's shovel and resume digging at a later date without losing anything but digging time.

Research and development, however, require a certain degree of continuity. The results of one experiment often suggest variations in the next, and investigators should be encouraged to explore new bypaths that may appear before the trails grow old. The history of science is replete with instances where discoveries of great importance have been made by following clues uncovered in the course of a routine test.

Nearly all the work done in the past has been for the purpose of providing a usable material for some specific component of some specific missile. As a result, there has been a lack of the generalized but coherent approach which distinguishes a science from an art. Only in recent years has there been anything resembling a general attack on the problem of missile materials.

Materials research and development falls logically into three categories, according to its objectives:

1. To determine the service adaptability of existing materials.

2. To produce new and better basic materials, formulations, and processes.

3. To obtain the optimum utilization of available existing materials.

The work under the first category is necessary to make the best possible materials immediately available. In this way we have solved almost all the materials problems to date. Very few existing materials have been developed specifically for missiles. Most of those currently used in missiles were previously used in other fields and have been adopted by missile designers as stopgaps until more suitable materials become available.

A GOOD example is graphite, which has been used for many years for many things—from lead pencils to the massive electrodes of giant electric furnaces. Some of its physical properties have made it an attractive material, especially for rocket nozzles, and many designers are using it. Because graphite is not, by any means, an ideal nozzle material (mainly because of its softness and susceptibility to oxidation), it could be improved. Actually, it *has* been improved—but only on a laboratory scale. Nevertheless, to date, there is no graphite grade developed especially for use in missiles. Graphites currently available are substantially the same as those of the premissile era.

In all fairness, it should be mentioned that a concerted effort to improve graphite recently has been inaugurated. With exhaust temperatures beyond the sublimation point of graphite already forecast for the near future, however, this effort may turn out to be another instance of "too little and too late."

Activity under the second category appears to offer the greatest promise. The application of up-to-date knowledge of crystallography, solid-state physics, and polymer chemistry in the development of new basic materials, and the use in processing of extremely high temperatures and pressures, X-ray and gamma radiation, high-intensity magnetic and electrostatic fields, ultrasonics, etc., etc., singly or in combination, may well lead to unprecedented breakthroughs.

Such approaches are, in any case, vastly to be preferred over the alternative of endlessly mixing marginal or submarginal materials, then processing the mixtures in various ways in the hope that the resulting product will—somehow—be superior to its constituents.

The third category includes the development of engineering designs that exploit the desirable properties of materials and, at the same time, avoid the exposure of materials to conditions under which they might fail. This entails the acquisition of data on the properties of materials at elevated temperatures (an area in which there is a pathetic lack of information at present), studies of the effects of high heating and loading rates on the strength of materials, and investigations of the mechanisms of heat transfer and dissipation. This category also includes the development of devices or methods for protecting materials from those features of the missile environment which they are unable to withstand.

This work has both a short-range and a long-range objective; to "make do" with existing materials until better ones are forthcoming, and to make it possible to "design around" future temperatures when they become so high that no possible form of matter can withstand them.

When that time comes, missile designers will have to depend on "gimmicks" like that developed for the small rockets of a decade ago in which the creep and stress-rupture properties of metals under extreme rates of loading were exploited to the ultimate. Thin-walled tubes, capable of withstanding only 1,500 p.s.i., were used successfully as motor tubes for rockets which developed internal pressure, during firing, of more than 2,000 p.s.i. The "gimmick" in this instance was explained quite simply: "We don't give it time to fail."

"The most refractory materials known at present have melting points in the vicinity of 7,000 degrees Fahrenheit. With propellant temperatures constantly increasing, it is obvious that in the near future no materials now known will be able to confine and direct the flow of combustion gases. . . . Despite the critical importance of materials, which should certainly be self-evident to anyone associated with the missile field, materials research and development is generally considered ancillary to other phases of a missile project. Too often the work is supported only to a point where a barely adequate material is developed, with no opportunity for further improvement, development of alternate materials, or cost reduction."

The technology of high-temperature materials is primarily the offspring of ceramics and metallurgy, but polymer chemistry—both organic and inorganic—has for some time been contributing significantly to its growth. As may be seen in the foregoing paragraphs, a number of other technologies also are involved.

This mixed parentage has resulted in some difficulties in communications between workers in the field. The development of a system of nomenclature is essential to the dissemination of information and cross-fertilization of ideas.

It seems apparent that the research, development, and engineering of materials to be used in thermal environments comparable to those to be found in the nozzles and combustion chambers of rockets has advanced far enough and is so important a factor in future rocket and missile development that it should be recognized as a separate field. This would serve to encourage a more generalized approach and would make it easier to take research and development of missile materials out of the "service" category.

There seems to be a general feeling in the missile field that the necessary materials always will be forthcoming or that a design "gimmick" of some kind always will be possible when needed. This faith in the ability of those engaged in materials development and engineering is touching—but not very realistic.

IN the foregoing, emphasis has been placed on materials for use in the high-temperature, erosive environments of rocket propulsion systems. There is also, of course, a pressing need for improved materials having special physical and chemical properties for use in more moderate environments, such as those of guidance packages, warheads, satellites, etc.

At present, however, it appears that the lack of adequate high-temperature materials may well be a barrier to any significant future development in rocket propulsion based on chemical fuels.

What's Up There?

Ordnance Ballistic Research Laboratories probed the upper atmosphere with fifteen sounding research rockets and eleven balloon flights hunting valuable data during recent International Geophysical Year

Spence T. Marks

THE interest of Aberdeen Proving Ground's Ballistic Research Laboratories in upper-atmosphere research grew from its responsibility for ballistic range instrumentation at the White Sands Missile Range, N. Mex., beginning in 1945.

With the advent of detailed planning for the International Geophysical Year in 1953, the BRL broadened their upper air research program, serving first as a member of the Special Committee for the IGY responsible for planning the U. S. rocket research program, next as a member of the technical panel on rocketry of the U. S. National Committee for the IGY, and finally as a participating scientific agency.

The Ballistic Research Laboratories were one of approximately eight agencies and institutions which actively participated in the U. S. IGY rocket research program. BRL experimental results are summarized here.

DURING the IGY, BRL assembled and fired a total of fifteen Nike-Cajun rockets. This solid rocket combination employs the booster of the Nike Ajax antiaircraft missile for the first stage and a Cajun rocket for the second stage. These units have thrusts of the order of 45,000 pounds and 8,500 pounds, respectively.

The complete rocket assembly weighs approximately 1,600 pounds and is about 25 feet in length. Burning times are approximately three seconds for each rocket unit, and a 15-second coast period between stages was chosen.

Mr. Marks is a physicist in the Ballistic Measurements Laboratory, Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

Performance tests were a necessary part of the BRL rocket research program. A test rocket was fired at White Sands Missile Range by BRL during the pre-IGY period to determine the suitability of the Nike-Cajun rocket for carrying the various IGY experiments to the desired altitudes.

The rocket was tracked by Askania cinetheodolites during the early part of its flight and by radar and DOVAP equipment during the remainder of the flight. A peak altitude of one hundred miles was reached, and impact occurred on range about twenty-seven miles northeast of the launch site.

Typical plots of Nike-Cajun speed versus time, altitude versus time, and altitude versus range were obtained from this rocket flight, and a realistic unit wind effect emerged from an evaluation of the flight data. Telemetered nose-cone temperature data indicated that ordinary steels or aluminum could be used for Nike-Cajun nose cones and that thermal insulation of the instrumentation compartments of Nike-Cajun nose cones would not be required.

A second test rocket was fired at Fort Churchill by BRL at the beginning of the IGY period to check the performance of a modified igniter after a Cajun misfire occurred, jeopardizing the IGY rocket-firing program. Both rocket stages ignited, and an altitude of 74 miles was attained. It was concluded that the misfire was caused by a firing-line failure, and not by the modified igniter.

Received signal strength, forward and back power, and DOVAP antenna temperature measurements made during this flight indicated that detuning effects from launch until second stage burnout were associated with high surface heating rates and/or drag, and were not caused by heating of the antenna tuning blocks.

DURING the second half of the flight, however, the temperatures of the antenna tuning blocks became high enough to account for the observed detuning effects.

A third test rocket was fired at Fort Churchill by BRL part way through the IGY period to determine the flight characteristics of a Nike-Cajun rocket with an exceptionally long and heavy nose cone. This rocket broke up at the end of the boost phase. However, the flight data obtained indicated that the chances of successfully flying long and heavy nose cones on Nike-Cajun rockets would be good provided that elevation angles in the order of 85 degrees or greater were employed.

Little quantitative information exists on water-vapor concentrations in the stratosphere and mesosphere regions of the upper atmosphere, although water vapor is a very important atmospheric constituent. It plays a large role in the

transport of heat energy from the tropics to the poles and, through the "greenhouse" effect, is responsible to a considerable extent for the existing heat balance of the earth.

One Nike-Cajun rocket with a water-vapor experiment was fired at White Sands Missile Range by BRL during the IGY. A sun-follower and infrared hygrometer were employed in the nose cone of the rocket. The sun-follower mechanism oriented an optical system toward the sun, and a reflection grating, followed by a pair of slits, separated the 1.26-micron reference and 1.38-micron absorption bands.

A mechanical chopper alternately cut off the light from each slit. After passing through the slits, the light was incident on a lead-sulfide photoconductive cell. The difference in resistance of the cell when exposed alternately to the two wave lengths constituted a measure of the amount of absorption due to water vapor.

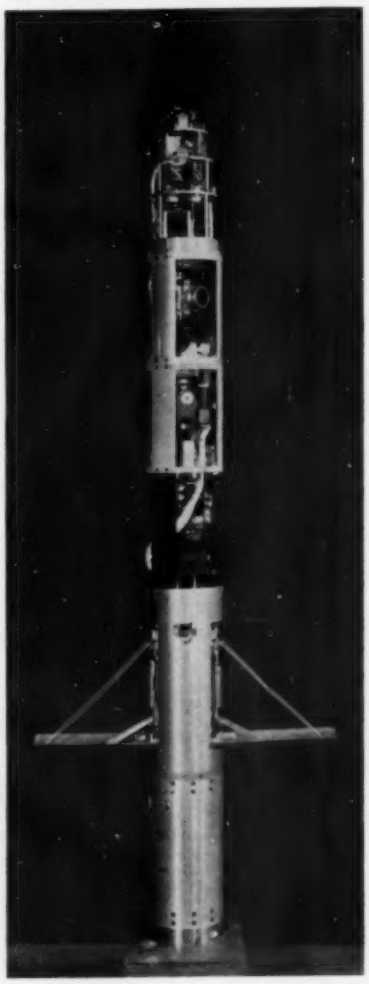
UNFORTUNATELY, both DOVAP tracking data and water-vapor data were lost after twenty-eight seconds of flight because of a failure in the DOVAP ground transmitter. Work continued on an improved version of this experiment during the remainder of the IGY period, and several water-vapor rocket firings were scheduled for the post-IGY period at Fort Churchill.

Short-term variations in the earth's magnetic field have been attributed for many years to the existence of tidally induced motions of charged particles in the lower ionosphere. The nature of the resulting currents—particularly in the auroral regions—is of great geophysical interest.

One Nike-Cajun rocket was fired at White Sands Missile Range and three Nike-Cajun rockets were fired at Fort Churchill by BRL during the IGY to measure magnetic field strength and direction, and efforts were made to detect large electric currents by observing their effects on the local magnetic fields.

A proton precession magnetometer with two heads, manufactured by Varian Associates, was used for magnetic-field measurements as shown on page 436. When the magnetometer is placed in a field of absolute intensity F, the protons of the magnetometer fluid precess about the earth's magnetic lines of force at an angular frequency ω.

Above, Arctic horizon photographed at an altitude of 7 miles by cameras in nose cone of Nike-Cajun rocket shown below.



The frequency of precession is directly proportional to the intensity of the magnetic field, $f = 4257.6\ (H)$, where H is in gauss, and 4257.6 comes directly from the atomic constants. Thus, by measuring the precessional frequency, the magnetic-field intensity can be determined. Field direction was measured using Schonstedt heliflux aspect sensors.

Data recovery from the White Sands firing was negligible because of a B+ supply failure in the rocket. However, good aspect and precession magnetometer data were obtained from the Fort Churchill firings, and later were drawn as a chart.

In photographs of the horizon taken during early V-2 rocket flights at White Sands Missile Range, and later balloon flights at Holloman Air Force Base, well-defined atmospheric haze bands were observed. The photographs obtained indicated that the height of the photometric horizon corresponded with the presumed height of the tropopause. A possible explanation of the multiple banding effect was that in mid-latitudes both tropical and polar tropopause effects can be seen. It was thought that camera-carrying rocket flights at Fort Churchill might resolve matters, since only the polar tropopause would be observable in the Arctic.

Seven Nike-Cajun rockets were fired at Fort Churchill by the BRL during the IGY to photograph the Arctic horizon. The first rocket contained two cameras each having a 36.5-degree field with their axes 180 degrees apart, as shown at the left.

THESE cameras were operated at two frames per second using Eastman high-speed infrared film. Exposures were two milliseconds at $f/11$ through a Wratten-type 89B filter.

A second design was similar to the first except that three cameras 120 degrees apart were used. Shutter action was initiated at X plus 27 seconds, and continued for 3 minutes and 20 seconds (400 frames). Shutter operations were telemetered until separation of the nose cone from the rocket occurred, at which time about 90 frames of film were left.

At separation, dive brakes were extended from the nose cone, which caused it to orient into a nose-down position upon reentry into the atmosphere. A parachute was then ejected, and a radio beacon turned on. The beacon

was tracked to determine impact location, and final recovery was accomplished by helicopter.

Excellent photographs were obtained from two of the rocket flights. A relatively simple banding structure was observed as compared to that seen in the middle latitudes. A typical horizon photograph is shown on page 435. The photograph was taken with the rocket at an altitude of forty-four miles. The rocket was quite stable at this point.

A second series of photos showed considerable yawing and precessing motion of the rocket at an altitude of fifty-five miles.

Mean values of the height of the photometric horizon obtained from these flights were 7.0 plus or minus 0.2 and 7.2 plus or minus 0.2 miles, respectively. These estimates are in good accord with the opinion that the photometric horizon in the Arctic represents the polar tropopause.

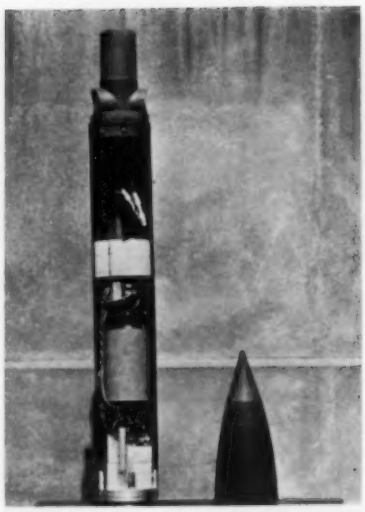
THE water-vapor and horizon study experiments of the BRL rocket research program required independent water-vapor data for calibration and comparison purposes at altitudes ranging up to 130,000 feet. Moreover, water-vapor data were of interest in connection with studies of atmospheric structure.

Eleven 7,000-gram balloon launchings were conducted by BRL at Aberdeen Proving Ground, White Sands Missile Range, Fort Churchill, and Fort Monmouth during the IGY and post-IGY periods for these purposes.

Modified dew-point hygrometers, originally developed by New York University for the Naval Bureau of Aeronautics, were flown on five of the balloon flights. This instrument is shown on page 437. One end of a silver rod, shaped like a capital T, has a mirror-like surface. The other end of the rod is immersed in a dry-ice and alcohol bath.

The mirror is cooled by conduction through the rod until moisture condenses from the air onto its surface. The size of the frost spot is controlled by inducing warming eddy currents in an iron band around the periphery of the mirror. Regulation of the eddy currents is accomplished by means of a feed-back system consisting of a light source and two photo tubes arranged in a bridge circuit.

A thermistor is imbedded in the surface of the mirror at the edge of the frost spot, and the temperature recorded by this thermistor is the true dew point of the ambient air. The ambient air temperature is obtained by means of another thermistor. Relative humidity and number density (absolute humidity) can be calculated from these data. Carbon and lithium chloride strips provide independent relative-humidity data at altitudes below 30,000 feet.



Nose cone with proton precession magnetometer measured high magnetic fields.

Altitude profiles are calculated from pressure measurements which are obtained from a carbon disulfide boiling point hypsometer at altitudes above 80,000 feet, and from an aneroid barometer at altitudes below 80,000 feet. In addition, mixing ratios can be calculated from the dew-point temperatures, the ambient temperature, and the pressure data.

The dew-point hygrometer was used in conjunction with a radiosonde package consisting of a modulator, Signal Corps AN-AMT-42(XE-1), and a transmitter, Signal Corps T-304-AMT-4A. Ground reception and recording were achieved by using a GMD-1 meteorological receiver.

Four layers of water vapor were recorded between 9.5 and 18.5 km. on a flight conducted at White Sands Missile Range. The number density of the layer at 9.5 km. ($2.1 \times 10^{15}/cm.^3$) was essentially 8 times as great as that of the layer directly above it. It is thought that similar layers are the cause of the multiple horizons that have been photographed from balloons and rockets.

Two flights, one at Fort Churchill, and one at Fort Monmouth, indicated that a considerable amount of water vapor was present in the lower and middle stratosphere. It is thought that these data are significant in view of the belief of some investigators that water vapor is practically nonexistent in the stratosphere.

Groups of coated and uncoated thermistors were flnown by BRL on six balloon flights to obtain atomic recombination data in the atmosphere. One group of thermistors was coated with metallic silver, which was considered to be a catalyst for the recombination of oxygen atoms. A second group was coated with aluminum oxide. This surface was considered to be specific for the recombination of hydrogen atoms and hydroxyl radicals.

A third group was coated with nickel. This surface also was considered to be specific for the recombination of oxygen atoms. The last group was flown late in the program to resolve ambiguities in the early results.

Positive recombination results were obtained between 33.2 and 36.6 km. on a flight at Fort Monmouth. An atomic oxygen concentration of 1.0×10^{11} atoms of oxygen per $cm.^3$ was indicated at an altitude of 35 km. on this flight.

These experiments have demonstrated that the method of using specific catalytic surfaces to obtain recombination data is feasible and that it yields positive results. However, the interpretation of the data is an extremely difficult task, and it would appear that additional laboratory studies are needed to specify the reactions which are associated with each catalytic surface.

A TRAJECTORY-comparison method for obtaining electron densities from DOVAP data was developed by BRL in 1950. In this method the DOVAP trajectory obtained for the rocket flight was compared with a vacuum trajectory. A small program was initiated at the time to obtain electron-density data from V-2, Bumper V, and Viking rounds which attained a sufficiently high altitude to be of interest and for which satisfactory DOVAP data were available.

The BRL-IGY rocket research program was formulated with this DOVAP electron-density capability in mind. All BRL rockets carried DOVAP for electron-density measurements and, in the case of the magnetic-field experiments, electron-density reductions were essen-

tial for proper interpretation of the data.

Efforts were made during the IGY period to develop improved methods for handling the DOVAP electron-density data, and suitable computer routines were worked out for the purpose. The pre-IGY Nike-Cajun test round was reduced during this program, and the electron-density data for this flight agreed favorably with the results of independent observations of ionospheric structure (P′-f records).

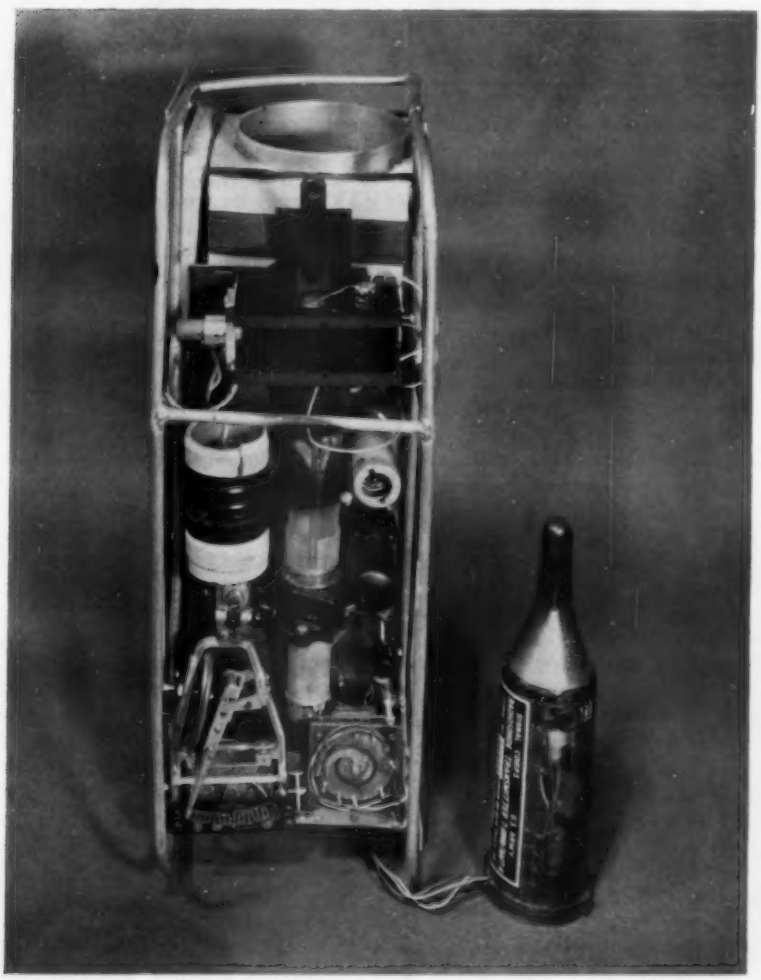
The Fort Churchill IGY rocket firings were screened at the close of the IGY period, and it was determined that approximately twenty-five of the firings met the necessary conditions for electron-density purposes. A post-IGY program was initiated at BRL to make these reductions.

A second method for obtaining ionospheric parameters from IGY-DOVAP data was developed during the post-IGY period. This method employed an analysis of the Faraday rotation of the DOVAP signal. It was used primarily to obtain total electron content rather than local electron densities. The method provided a relatively independent measurement of ionospheric parameters, and served as a check on the results obtained by the trajectory-comparison method.

A comparison was made of three up-leg electron-density determinations for one of the highest flights at Fort Churchill during the IGY. The up-leg of an ion density determination for the same flight was included also. The latter data were obtained from a Langmuir probe experiment conducted by the University of Michigan. This project was sponsored jointly by the Ballistic Research Laboratories and the Air Force Cambridge Research Center.

It is interesting to note that one of the P′-f reductions (first reflection height assumed at 150 km.) is in good agreement with the DOVAP trajectory-comparison reduction, while the other P′-f reduction (first reflection height assumed at 120 km.) agrees rather well with the Faraday rotation and ion-density reductions.

A modified dew-point hygrometer, one of several flown on five balloon flights, recorded valuable water-vapor data.



FOLLOWING the IGY, the Ballistic Research Laboratories embarked upon an upper-atmosphere research program whose purpose was the continuation and extension of the programs begun during the IGY period.

Electron-density reductions for IGY rocket flights were continued, and a significant advance was made in November 1959 when excellent electron-density data were obtained to an altitude of 1,500 km. from a 5-stage rocket firing (Strongarm I) at Wallops Island, Va.

A water-vapor rocket flight was flown in April 1960 at Fort Churchill, and balloon-borne dew-point hygrometers were flown simultaneously at five locations ranging from Thule, Greenland, to Albrook Air Force Base, Panama. The results indicated that the stratosphere was extremely dry in the northern latitudes.

Additional Strongarm firings to obtain electron-density data were scheduled for midsummer 1960 at Wallops Island, and several water-vapor rockets will be fired this fall at Fort Churchill.

In addition to this upper-air research the Ballistic Research Laboratories also conduct basic technical research in ballistics and in the related fields of physics, chemistry, mathematics, and engineering. A staff of scientific specialists render otherwise unavailable services to the Ordnance Corps, to other Government agencies, and to their contractors in the fields of interior, exterior, and terminal ballistics; instrumentation for ballistic measurements; computing techniques; weapon systems analysis and development; and quality control.

They also render expert consulting services in connection with the design of new weapons, the more effective use of existing ones, and suggested avenues for research and development which will lead to new weapons. The laboratories also prepare ballistic tables for guns and rockets.

Rocket Thrust Control

The split-second termination of the power of a solid-propellant rocket can be achieved by the use of an exploding bridgewire system that opens vent ports to allow pressure to escape and negate thrust

Kenneth A. Johnson

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A PARADOX exists in the choice of solid-propellant rockets as the answer to problems of reliability, storage, and safety in missile and space-vehicle systems. The very dependability of the solid propellant presents missile and space-vehicle engineers with a major problem in thrust control and termination.

Solid propellants, once fired up, are not easily quenched. But the success of the missile or space vehicle is largely determined by the exactness with which acceleration, velocity, and position can be controlled as a function of time, and these parameters directly relate to the rocket's thrust history.

THE only consistently successful method of thrust termination of solid-propellant rockets currently available to engineers is that of negating the forward thrust. This is accomplished by opening large areas in the forward area of the rocket to produce a counterthrust and reduce the internal pressure to the point that no forward thrust is developed. Figure 1 shows a simplified diagram of this technique. To prevent the blast of vented gas from disturbing succeeding stages, areas are opened along the periphery of the rocket body so that the gases are directed outward and away from the next stage mounted forward of the vented rocket.

The pressure-venting method of thrust termination introduces need for a technique of rigidly controlled (with respect to time and shape) creation of venting ports. The time requirement is critical. The success of the missile or space vehicle is largely determined by the temporal exactness with which dynamic parameters can be controlled. Therefore, since these parameters are all functions of the thrust-time history, they directly affect thrust-control accuracy.

Any effort to establish a definite acceleration, velocity, or position at a given time requires an exact control over the thrust characteristics. Any variation in thrust-time history from that prescribed for the mission produces corresponding or greater variations in the parameters of acceleration, velocity, and position.

Deviations in the trajectory of the successive stages of the vehicle can be introduced by nonsymmetrical thrust vectors created when the internal pressure is vented to terminate rocket thrust. These nonsymmetrical vectors are caused by either the actual areas of the venting ports being nonsymmetrical with regard to the vehicle axes or by the vent areas, though symmetrical, being created at slightly different times. The extent of the deviation in trajectory will be a function of the nonsymmetry of the areas and of the time difference in the formation of the vent areas.

The engineer must develop a method of forming the venting ports accurately and in synchronization. Complicating these specifications are the ever-present requirements of reliability and safety.

TO satisfy the requirements for uniform and accurate vent area formation, engineers at the Sunnyvale facilities of Librascope Division, General Precision, Inc., decided on a design in which the area, configuration, and arrangement of the vents would be predetermined before actuation. The actuation mechanism would have only the function of initiating the chain of events leading to the formation of the vent areas. Even the forces necessary physically to displace the venting port elements would be obtained by utilizing the internal pressure of the rocket.

Figure 2 shows a vent port designed for a rocket motor such as used in a typical IRBM. The formation of a venting area is accomplished by the ejection of a dome from the port. A retaining ring holds the dome in place until the thrust-termination system is actuated. Several of the port assemblies can be arranged around the periphery of the rocket casing as shown in Figure 1.

The retaining ring holds the dome in place against the internal rocket pressure until the time of actuation. At actuation, a frangible sector in the

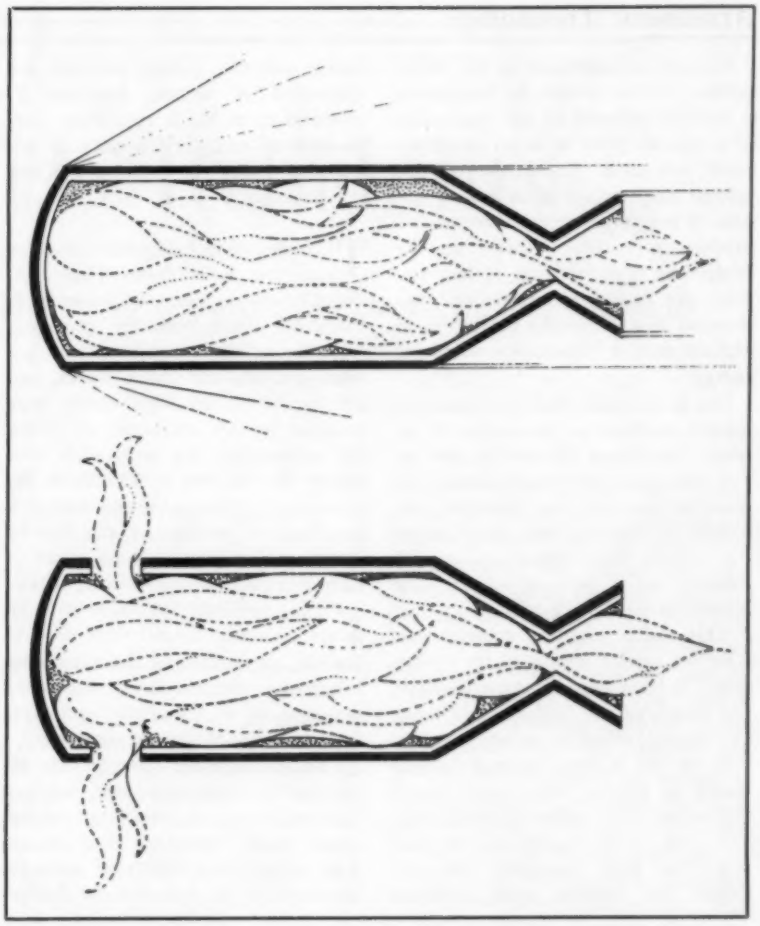
retaining ring is exploded under the action of an exploding bridgewire. This frees the ring and permits the internal pressure of the rocket to eject the dome, and the internal pressure is vented uniformly from the several ports. In a typical configuration, total relief is accomplished in less than 2.2 milliseconds.

Since the shape of the port predetermines the shape and size of the vent area, there is no opportunity for nonsymmetrical thrust vectors to be generated on the basis of nonsymmetrical vent areas. The dome and retaining-ring designs provide minimum friction conditions between the ring and dome and port during ejection, ensuring that perfect symmetry is maintained and that there is no opportunity for domes to fail to uncover the vent areas.

This is a decided advantage over some contemporary designs which vent the rocket by explosively rupturing areas in the casing. These techniques are generally unsatisfactory from the standpoint of nonsymmetrical thrust and even of incomplete venting.

Full effectiveness of the technique for creating symmetrical vent areas can be achieved only if the vent areas can be generated with split-second response to commands from guidance and control systems. These actuation orders must be carried out simultaneously by the full complement of vent ports ringing the rocket case. To provide thrust termination with maximum reliability of actuation and with a minimum of delay between issuance of the actuation command by guidance and control sources and actuation, an exploding bridgewire initiation system was developed.

The exploding bridgewire (EBW) element forms the frangible sector which holds the retaining ring in place until actuation. This technique provides a safe and reliable actuation mechanism which generates multiport vent areas with a simultaneity of twenty microseconds. When the actuation command is received by the EBW initiator, the bridgewire is exploded, destroying the frangible sector and permitting the retaining ring to release the dome. The internal pressure then forces the dome from the port to vent the internal pressure and terminate thrust.



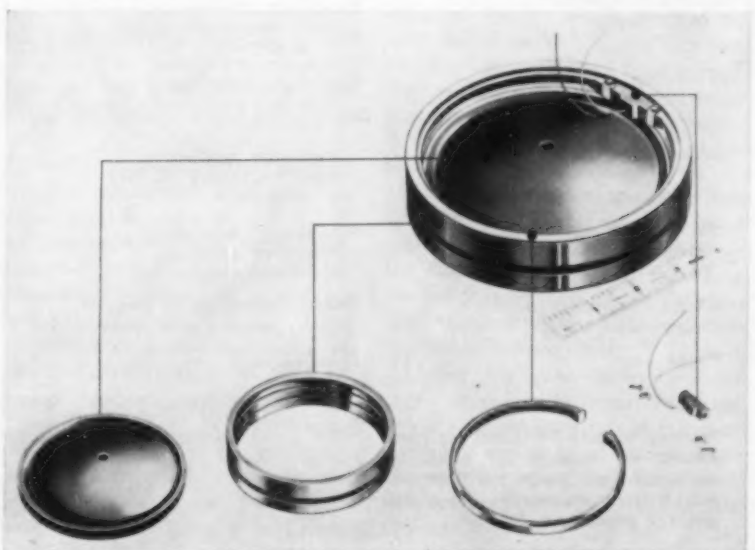


Fig. 1, above, shows method of negating forward thrust of solid-propellant rocket by venting internal pressure through openings in forward portion of rocket casing. Fig. 2, below, exploded view of vent elements shows dome, left, retaining ring, center, frangible sector, right. Upon actuation, bridgewire explodes frangible sector, freeing retaining ring; pressure ejects dome.

Principle of operation of the EBW initiator system is that the bridgewire is actually exploded by the application of a current pulse with an extremely rapid rise time. Application of this current pulse, which must have a rise time of less than one microsecond and produce a current density in the bridgewire of at least one million amperes per square centimeter of cross sectional area, causes the bridgewire to explode with a tremendous release of energy.

Due to this skin effect, the current is initially confined to the surface of the wire. This causes the wire to heat up and melt from the surface toward the center of the wire. Simultaneously, the concentric magnetic field, generated by the current flow, exerts an inward-directed radial pressure on the wire known as the "pinch effect."

This radial magnetic pressure acts with the surface tension of the molten metal to form beads of material along the length of the bridgewire. During this period, effective surface temperature of the molten material is estimated at greater than 5,000 degrees Fahrenheit. The molten globules separate, causing the current to cease flowing. The radial magnetic field collapses, the inward radial pressure ceases, and the molten particles are accelerated in random directions at velocities up to Mach 150. These phenomena all occur in less than 10 microseconds after the application of the current pulse.

THE exploding bridgewire produces energy in varied forms. These consist of heat from the melting wire itself, the shock wave from the exploding wire, the adiabatic compression of gas from pressure and shock waves, and the friction of the high-velocity wire particles as they encounter the material surrounding the bridgewire. This energy can be used to accomplish the initiation or, where additional energy is required, the bridgewire can directly initiate a secondary explosive which in turn accomplishes the desired action.

Photographic studies made with an image converter camera were used to analyze the nature of the exploding-bridgewire phenomena and led to the development of the EBW technique for practical ordnance applications.

Outstanding safety feature of the exploding-bridgewire technique, whether it is to be used in thrust termination, rocket motor initiation, stage separation, or any of a variety of ordnance functions, is the fact that the bridgewire can be exploded only by the application of a high-amplitude current pulse with a rapid rise time. Pulses of the required magnitude and character are alien to any other portion of missile or space-craft systems.

The exploding bridgewire initiator system consists of these elements: firing unit, bridgewire, and the secondary explosive. The firing unit receives the actuation command signal from the missile or space-vehicle command source, usually the guidance and control system or ground command transmission, and generates the firing pulse to be applied to the bridgewire.

Firing unit power requirement from the missile system is extremely low and is a function of arming time. Typically, with a charge time of 1.8 seconds, the current peak is 4 amperes with a steady-state current of 0.04-ampere. EBW systems normally employ a 28-volt d.c. input. However, the firing unit can be designed to accept any input voltage.

Firing unit weights vary in accordance with the number of functions and initiators in the system. A range of weights from 3½ through 7 pounds would be typical for a 1-point to a 15-point system.

THE bridgewire itself can be adapted to any number of ordnance device configurations. EBW initiator systems may be used for rocket motor initiation, for stage separation by MDF (mild detonating fuze) or bolt fracturing, and for other missile ordnance functions.

An added advantage of the EBW system is the saving in weight. Conventional squib- or detonator-initiated thrust-termination means require out-of-line blocking systems and other precautionary equipment to ensure the safety of the system. Since this is not necessary in the case of the EBW, weight savings per port of 4 to 5 pounds can be realized. Table 1 presents the weight comparisons of a multifunction initiator system in a typical IRBM missile.

Table 1. Estimated weight comparison of exploding bridgewire system and explosive system in a typical intermediate range ballistic missile.

Bridgewire System	*Pounds*	*Explosive System*	*Pounds*
First-stage ignition *EBW igniter*	0.5	First-stage ignition *Squib mechanical blocking device*	5.0
First-stage separation *EBW primacord initiator*	0.3	First-stage separation *Primacord mechanical blocking system*	5.0
Second-stage ignition *EBW igniter*	0.5	Second-stage ignition *Squib mechanical blocking device*	5.0
Second-stage separation *EBW primacord initiator*	0.3	Second-stage separation *Primacord mechanical blocking system*	5.0
Thrust termination (6 ports) *Ring, dome, and EBW sector*	9.0	Thrust termination (6 ports)** *Spider network with detonator*	36.0
Firing unit*	4.5	None required	0
Total	15.1	Total	56.0

**Cabling between firing unit and components not included but would be comparable to explosive system. High-voltage transmission line would weigh 2 pounds per 100 feet.*

***No mechanical blocking system included.*

EDITOR'S NOTE.—In recent weeks new developments and improvements have been effected in the exploding-bridgewire field, and it is planned to discuss them in an early issue of ORDNANCE.

Vehicle Reliability

Industry and the military must cooperate to achieve the desired goals

Errol J. Gay

Mr. Gay is an engineering consultant, Detroit, Mich., and chairman of the A.O.A. Engine and Power Train Section of the Combat and Tactical Vehicle Division.

IN April 1959 the Ordnance Tank-Automotive Command at Detroit issued Instruction 705-2 entitled, "Research and Development of Matériel—Reliability Objectives." Paragraphs (a) and (b) under Item 6 (Policy) are quoted herein:

"a. During Phase I (1960-1963), ground vehicles should have a ninety per cent probability of completing the following mileages in a military environment:

"1. Wheeled and tactical vehicles: 10,000 miles with only organizational (first- and second-echelon) maintenance, and 20,000 miles with only organizational (first-, second-, third-, and fourth-echelon) maintenance.

"2. Tracked vehicles: 2,000 miles with only organizational maintenance and 4,000 miles with only organizational and field maintenance.

"b. During Phase II (1964-1970), ground vehicles should have ninety per cent probability of accomplishing the following in a military environment:

"1. Wheeled and tactical vehicles: 25,000 miles with only organizational maintenance.

"2. Tracked vehicles: 5,000 miles with only organizational maintenance."

THE above reliability objective is an excellent move in the right direction. A dividend resulting from this objective should be a reduction in spare-parts requirements and in the maintenance labor force. If these objectives are to be attained in part or in their entirety, the military and its top civilian agencies must understand that more time will be required and greater cost incurred both for the development of the vehicle and for its purchase.

The Combat and Tactical Vehicle Division of the American Ordnance Association has presented many examples of the need to design and build durability into vehicles if the above objectives are to be accomplished. One example was the transmission weight of the famous 2½-ton, 6 x 6 truck—1.4 pounds per horsepower or almost exactly the same as that of a conventional, commercial on-highway vehicle of the same gross weight.

However, a commercial off-highway vehicle of the same gross weight would use a transmission weighing almost 2.0 pounds per horsepower, providing more gear and bearing capacity which should result in a longer life expectancy.

There is an opinion among the services that commercial off-the-shelf vehicles would fit military needs if only the automotive industry would build them satisfactorily. This is not true. Commercial vehicles *per se* will not meet military needs.

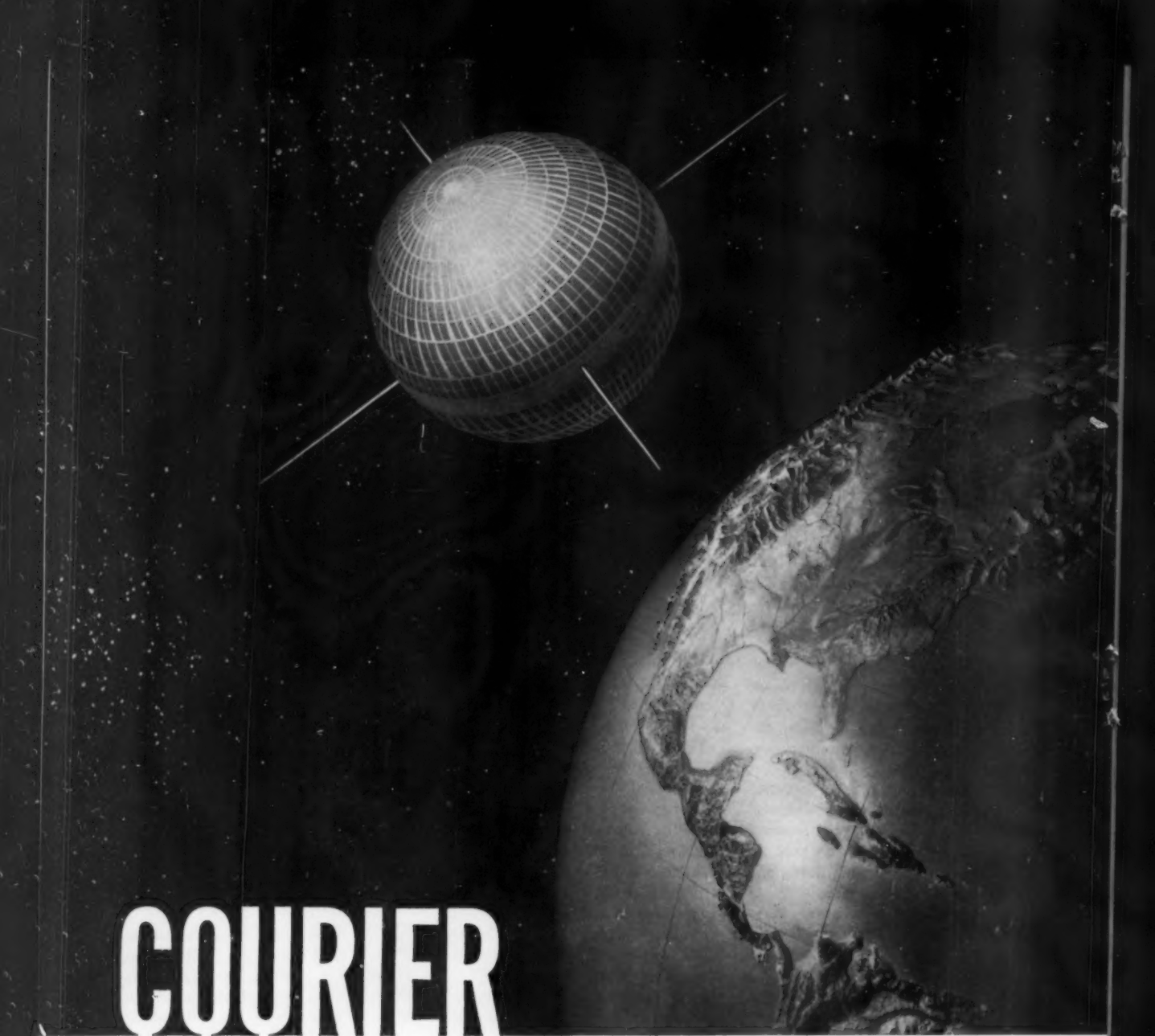
However, it is true that minor redesign of off-the-shelf items can often meet the military requirements. This is proved every day by the performance of equipment in the earth-moving and construction industries and by heavy-duty bus and truck fleets. Many heavy-duty gasoline and diesel engines are guaranteed for 100,000 miles, and many fleets expect 250,000 miles from an engine before major overhaul. Total chassis life often reaches 750,000 to 1,000,000 miles before the vehicle is replaced.

There is one major difference between the Army and civilian fleets in regard to maintenance. The civilian fleet keeps its maintenance at an absolute safe minimum. Brakes and steering, the safety items, are constantly checked, but axles, transmissions, and engines may go 60,000 to 100,000 miles before being opened for inspection or repair. Due to training needs, the Army has overmaintained its vehicles, and this invariably will shorten vehicle life.

THE above objectives will require more time for the development period of a vehicle. Industry knows through many years of experience that even with the best design staff and the most skilled model shop, the first prototype vehicles will need "debugging." This is the reason for large test facilities that cost many millions of dollars. A conscientious bidder will allow for this in his proposal.

The military must recognize this situation and evaluate contracts based on the ability of the bidder to produce the desired results. When estimating production schedules, long-range planning must provide for additional time in the development phase.

Giving only lip service to the intent of the above-quoted objectives will not produce the desired result of increased durability and reduced maintenance. Conscientious effort and hard work will be required from both the military and industry.



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The following companies have shown by their interest in the design and production of ordnance that they are ready to serve the United States through industrial preparedness for national security and peace. Such companies as these are indicative of the industrial strength of the Nation upon which the military might of the armed forces depends.

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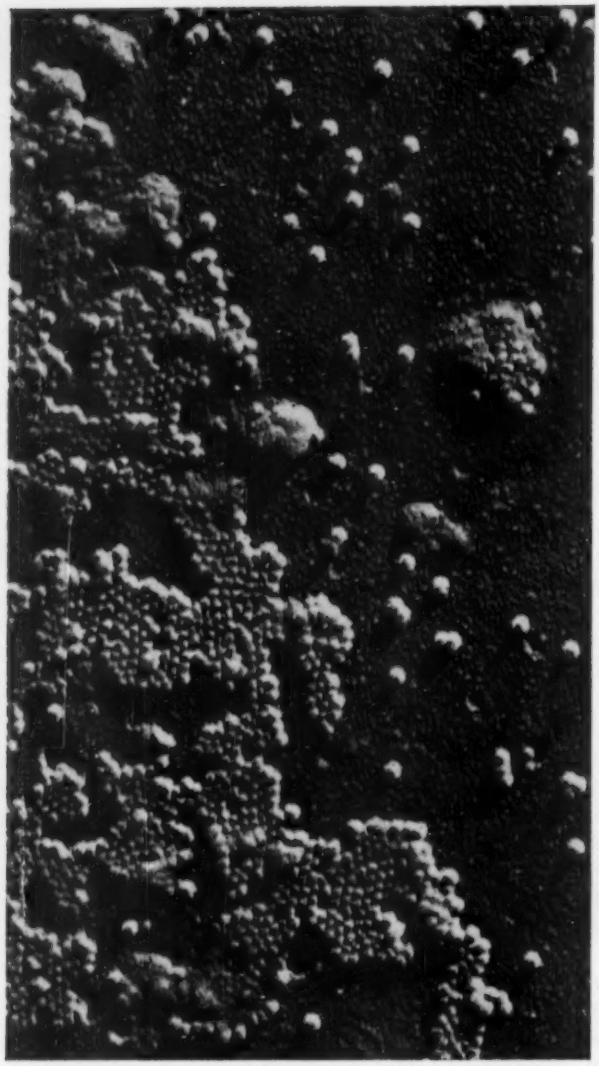

The virus of poliomyelitis, magnified 65,000 times by an RCA electron microscope. Photo by Dr. A. R. Taylor of Parke, Davis & Company.

This RCA electron microscope embodies all the many improvements born of more than twenty years' research and manufacturing experience.

Reproduced at the left is a photograph of the deadly polio virus—made visible for the first time with RCA's powerful electron microscope.

Viruses, one of man's deadliest enemies, could never be seen through ordinary microscopes. But with RCA's powerful electron microscope, scientists now can see them, study them, and learn how to fight them.

The electron microscope is *a thousand times more powerful* than ordinary microscopes. It can magnify an object 1,000,000 times. A pencil so magnified would be 119 miles long and 4 miles thick!

Today, this history-making "electronic eye" has a host of vital uses. In addition to its role in medical and scientific research, it has helped to make automobile tires wear longer, synthetic fabrics more durable and metals stronger. In fact, almost every product you buy is better in some way because of the RCA-developed electron super-microscope.

And now, so that many more may share its benefits, RCA has announced a long-term lease plan for its electron microscope. Interested? Write RCA, Industrial Electronic Products Division, Camden, N. J.

RCA skills and ingenuity gave man his first look into the world of the ultra-small. And these same skills assure the dependability of all the RCA Victor black-and-white and color television sets, radios, records and high-fidelity systems that you enjoy in your home.

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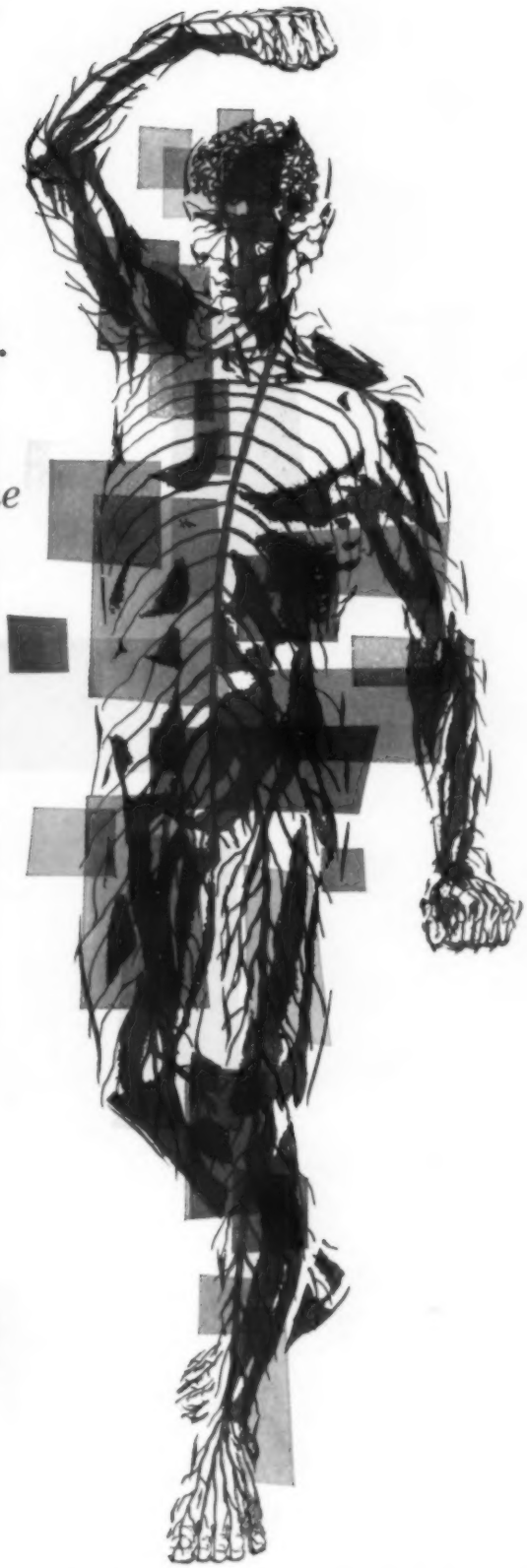

SYSTEMS ...*second to one*

Parsons' Electronics Division is actively engaged in the research, development, manufacture and installation of electronic systems for military and commercial applications. Current activities and fields of interest include:

- *Systems Engineering*
- *Telemetry Systems*
- *Miss-Distance Indicator Systems*
- *Timing Systems*
- *Space Positioning Systems*

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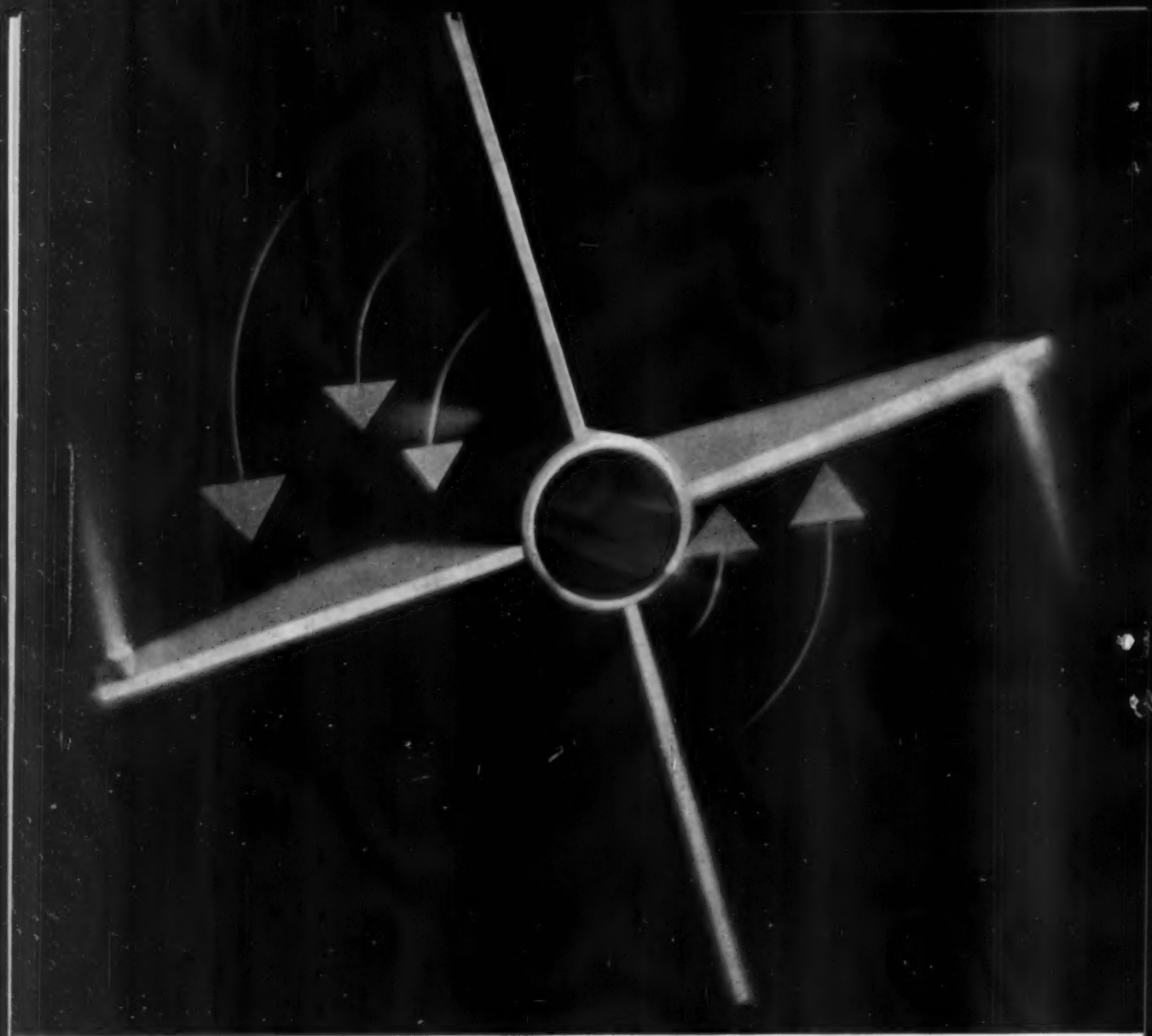

Reaction controls at work in space — symbolized.

STEERING GEAR FOR ASTRONAUTS

Conventional aircraft control surfaces will not guide space ships and capsules. Rudders, ailerons and elevators find no resistance and hence produce no reaction to their movements where there is no atmosphere. Even at altitudes only half way up, they are sluggishly ineffective.

The accepted answer to a dependable steering mechanism for astronauts is a system of jet reaction controls developed and produced by Bell Aerosystems Company. First used on Bell's own supersonic X-1B several years ago, the system has been greatly improved and adopted for the X-15, the Mercury man-in-space project and other space vehicles.

Through strategically located, low and high thrust (1 to 1500 pound) rocket engines, Bell's reaction controls not only position and guide the ship by controlling the roll, pitch and yaw, but they also provide for orbit changes and retro-thrust. Some of the jets are throttleable while others can be operated in combination to provide the astronaut positive and flexible control.

This revolutionary steering gear for space, available using monopropellants or high energy bipropellants, is just one of many advanced projects which are currently engaging the diversified talents of Bell Aerosystems Company in the fields of rocketry, avionics and space techniques. Engineers and scientists seeking challenging, long-range career opportunities can find them at Bell.

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